TEXT-BOOK
OF
LOCAL ANÆSTHESIA
HIRSCHEL

Text-Book of Local Anæsthesia.

FOR STUDENTS AND PRACTITIONERS.

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LOCAL ANÆSTHESIA

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STUDENTS and PRACTITIONERS.

BY

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With an Introductory Preface by Prof. Dr. WILMS.

With 103 *Illustrations in the text.*

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TRANSLATOR'S NOTE.

In presenting a translation of Professor Hirschel's Text-book of Local Anæsthesia, I may be permitted to make a few remarks regarding the translation itself. It is well to define the terms one uses, so as to avoid all misapprehension. In this connection I may mention that I have throughout employed the term "conduction-anæsthesia" instead of the more usual rendering "regional anæsthesia," as it seems to me that the former gives a more correct rendering of the German term "Leitungsanæsthesie," and further corresponds more nearly to such terms as "infiltration-anæsthesia," "spinal anæsthesia," "epidural anæsthesia," &c.

As regards the anatomical terminology, I have mainly employed the new terminology, as the plates of the German work were marked in this manner. Where there was any possibility of ambiguity, I have added the old terms in brackets. I have also used the decimetric system throughout.

The German original had no Index; I have thought it well to add one. The operations are collected under one heading, "Operations," and in some instances under their regional headings. The references to the technique for the induction of local anæsthesia by interrupting the conduction of the various nerves will be found under the heading "Anæsthesia, conduction, technique," each nerve being specified. The anatomical description of the distribution of the nerves will be found under the heading "Nerves." trust the Index may be found of some practical value to the reader.

RONALD E. S. KROHN.

London, March, 1914.

INTRODUCTORY PREFACE.

LOCAL and regional anæsthesia have nowadays assumed great importance in operative surgery, and almost every year new territory is conquered by them. In most clinics the number of general anæsthesias administered probably stands below that of the local anæsthesias induced. Even in the Heidelberg Clinic, which is known for its large proportion of laparotomies, in the year 1912 local anæsthesia accounted for 54 per cent. of all the anæsthesias employed. Although we cannot at present dispense with general anæsthesia in abdominal operations, even in this field a promising start has been made. Should local anæsthesia gain ground in this special department of surgery, only a restricted field will be left to general anæsthesia. Commensurately with the greater evolution of local anæsthesia the technique has become far more varied and many-sided; nay, in many cases nowadays it has become a procedure which from a technical point of view demands as much dexterity and experience as the operation itself. A most exact knowledge of the anatomy of the course of the nerves, careful administration of the injected fluids, considerate and delicate comportment when administering the anæsthetic, will be determining causes of success of local anæsthesia. In order to assist a plastic conception, which is the prime requisite for every conduction-anæsthesia, Dr. Hirschel has at my instigation collated the various methods of local anæsthetization in the present work. The satisfactory explanation of different complicated methods, so frequently far from easy in words alone, has been much facilitated by copious illustrations. Dr. Hirschel, who has himself done valuable service in this special field of medical science by his published work, and who has gained a wealth of practical experience, seems to me to be particularly fitted to elaborate the present theme. The illustrations have proved a valuable assistance to us in the clinic in the practical induction of local anæsthesia, and we therefore feel that they may likewise act as reliable guides to others

Heidelberg,
March, 1913.

Prof. WILMS.

AUTHOR'S PREFACE.

He who wishes to write a comprehensive treatise on the subject of local anæsthesia nowadays must begin with Braun and end with Braun. On the foundations which he has laid for this special branch of anæsthesia, the successes and the advance which have been gained in recent years have been evolved into a great comprehensive whole. The question of local anæsthesia cannot as yet, and will probably never be regarded as finally solved, for almost daily new modifications and improvements are reported in medical literature, and much that does not yet satisfy us awaits solution. A rich and undoubtedly successful field for research still lies before us. Nevertheless it would appear that a certain stage of completeness has been reached in this domain owing to the valuable results of the last few years' work.

An attempt to collect and sift the material at hand would therefore appear to be justified. In doing so, old approved methods must be re-emphasized and new methods must be added and critically examined and elucidated.

This is the task that I have set myself, and I have attempted to collate in brief all important and valuable facts relating to local anæsthesia that are now known and have been thoroughly tested.

Local anæsthesia has advanced fairly equally in all domains of surgery, including the special branches. We find it employed in ophthalmology, otology, laryngology, urology and in dental surgery; in gynæcology alone has it so far received but little attention. The reason for this is probably to be found in the fact that the nerves which innervate the female genitalia have a very complicated course and are difficult of access. Extradural anæsthesia seems to be destined to play a supplementary and successful *rôle* in this field.

Wheresoever these special departments of surgery overlap general surgery, they have received the consideration that was their due as regards the application of local anæsthesia. A knowledge of the course of the nerves is of the greatest importance for the technique and the successful induction of local anæsthesia in operative surgery. I have therefore, with the aid of illustrations, briefly described the anatomical course of the nerves supplying the various regions of the body. These illustrations have been borrowed by the courteous permission of both

authors and publishers from the atlases of Spalteholz, Corning, Hasse, and Toldt. Professor Fischer, of Marburg, also kindly placed a large number of illustrations from his work "Die lokale Anæsthesie in der Zahnheilkunde" at my disposal.

I trust that this work may prove an incentive for an even wider application of local anæsthesia in surgery and its special branches than has so far been the case.

Heidelberg,
March, 1913.

Dr. Georg Hirschel.

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TEXT-BOOK OF
LOCAL ANÆSTHESIA

A.—GENERAL SECTION.

Historical Survey.

BEFORE the discovery of cocaine and its local anæsthetizing properties it would have been impossible to have spoken of "local anæsthesia" in its modern sense. The introduction of cocaine laid the foundation for the study of the local prevention of pain which has achieved such brilliant results in recent times. Attempts at achieving the latter object had been made, it is true, and one need only refer to Richardson's ether spray, which he employed for the first time in 1866 for the purpose of anæsthetizing the skin, but this discovery can hardly be regarded as of fundamental importance. Still it shows that attempts to obtain local anæsthesia were not lacking even at that time, and it is possible that Richardson's results may have served to encourage further research in this field.

It was only after the introduction of cocaine into ophthalmological practice, which was initiated by Koller in 1884 at the Ophthalmological Congress at Heidelberg, that local anæsthesia was guided in a new and successful direction. Even before Koller, Scherzer had recognized the anæsthetic properties of the drug, when he observed that chewing coca leaves produces a numb feeling on the tongue.

Von Anrep tested cocaine on the eyes of animals and noted the mydriatic action which had been already previously recognized; he also injected it under the skin of his own arm in the form of a weak solution, and noticed that the cutaneous region thus treated became insensitive to the prick of a needle.

In the same year that Koller had recommended cocaine for operations on the eye, the drug was also used considerably in laryngology and rhinology. Otis and Knapp used it for anæsthetizing the mucous membrane of the male urethra; Fraenkel on the female genitalia. Subcutaneous injections of 2 to 20 per cent. cocaine were then

employed in surgery, and in dentistry the services of cocaine were also requisitioned.

In 1885 Corning made the discovery that when the circulation of the blood was simultaneously interrupted the action of cocaine was augmented. This discovery was important in that it now became possible to employ solutions of far lower percentage (0·25 to 0·3 per cent.), and thereby to diminish the risk of cocaine intoxication supervening. Roberts was able by this means to carry out an operation for partial resection of the elbow and an osteotomy painlessly. Soon after, a number of surgeons performed further experiments and operations, such as amputations, tracheotomies, herniotomies, &c., under cocaine anæsthesia, and published their results.

Already in 1885 Roberts described infiltrations in the skin which he extended peripherally by fresh insertions of the needle and injection, thereby rendering a wider surface of the skin anæsthetic. Reclus and Schleich developed this procedure into a definite method.

The first conduction-anæsthesia ("Leitungsanæsthesie")[1] was practised by Halstedt in 1885, when he injected cocaine along the main trunk of the inferior alveolar nerve from the buccal cavity.

Oberst, Pernice, and Kummer used this procedure of conduction-anæsthesia in the case of fingers and toes. By the injection of 0·5 to 1 per cent. solution of cocaine subcutaneously round about the first phalanx of the fingers or toes, and simultaneously constricting the corresponding limb, anæsthesia of the fingers or toes was induced in a few minutes. Oberst described this procedure in 1888, Pernice in 1890. It was only when Braun and Hackenbruch again drew attention to this method of inducing anæsthesia, however, that it became generally known and used.

Corning in 1885 made the important discovery that by injecting 2 to 3 per cent. solution of cocaine between the spinous processes of the lower dorsal vertebræ anæsthesia of the lower limbs was produced in a dog and a man. As is well known, the practical importance of this discovery was pointed out by Bier.

Although conduction-anæsthesia had already been employed in isolated cases, infiltration-anæsthesia was by far the more widely employed process in the early days of local anæsthesia.

To Reclus and Schleich we owe the technical perfecting of the infiltration method; isolated experiments had already been made, as we have mentioned, by various surgeons (Roberts), but it was Reclus

[1] *Note by the Translator:* The term usually employed in England is "regional anæsthesia." I have throughout this translation preferred to use the term "conduction-anæsthesia" which more correctly renders the German term "Leitungsanæsthesie," and at the same time suggests the fact that the anæsthesia is produced by interrupting the conduction of the nerve, just as infiltration-anæsthesia expresses the fact that the anæsthesia is produced by infiltrating the tissues.

and Schleich who raised infiltration-anæsthesia to the dignity of a method. It consists, in the main, in infiltrating the skin with cocaine solution by means of endermic injections, by successive series of wheals, and in permeating the subjacent layers of tissues with the same solution before incising them. Infiltration-anæsthesia is a nerve-end anæsthesia, the ultimate nerve-endings being bathed with the anæsthetic and rendered insensitive.

Reclus had already, in 1893, diminished the concentration of his cocaine solutions, he had decreased them first to 1 per cent. and later to 0·5 per cent. He did not restrict himself to minor surgical operations, but even undertook major operations such as herniotomy, resection of the ribs, and even abdominal operations under infiltration-anæsthesia. His method of procedure seemed so free from danger that he did not shrink from using doses of cocaine amounting to 0·2 grm. In Germany this method of Reclus did not find many advocates, probably on account of the large doses of cocaine employed.

Schleich proved that it was possible to reduce the doses of cocaine still further than Reclus had done. In 1891 he reported 224 operations including laparotomies, herniotomies, &c., which he had performed under anæsthesia induced with solutions of 0·2 per cent. cocaine, accompanied by the simultaneous use of ether spray. He had not exceeded doses of 0·04 grm. of cocaine. The freezing of the skin was only employed by him to render the skin insensitive to the prick of the needle. We now know that cooling the skin enhances the action of the cocaine.

The solutions employed by Schleich were as follows :—

I.	Cocainæ hydrochlor....	0·2
	Sodii chloridi... ...	0·2
	Morphinæ hydrochlor.	0·02
	Aq. dest.	100·0
II.	Cocainæ hydrochlor....	0·1
	Sodii chloridi... ...	0·2
	Morphinæ hydrochlor.	0·02
	Aq. dest.	100·0
III.	Cocainæ hydrochlor....	0·01
	Sodii chloridi... ...	0·2
	Morphinæ hydrochlor.	0·005
	Aq. dest.	100·0

The solutions II and III were the most commonly used, solution I being employed for anæsthetizing severely inflamed tissues. Schleich attributed a local action to the added morphia. Among others, Braun pointed out Schleich's error, and emphasized the fact that the action of the morphia was purely general. The same solutions deprived of the added morphia produced precisely the same local action as Schleich's, which contained it.

Later, β-eucaine was introduced by Braun, Reclus and Legrand, and tropococaine by Custer, as substitutes for the toxic cocaine. The

short duration of the anæsthesia produced by the same concentrations of eucaine as compared with that produced by cocaine was a drawback, as was also the incomparably greater time taken for them to act. The percentage of eucaine had to be doubled, and that of tropococaine to be increased five to eight-fold before their action equalled that of a cocaine solution of the same efficacy.

Hackenbruch, Gottstein, Legrand and others, recommend combinations of cocaine and eucaine.

Whereas in the case of infiltration-anæsthesia, the nerve-endings, in or under the skin, are rendered insensitive by being bathed in the anæsthetic agent, by the term conduction-anæsthesia we understand the interruption of the conductivity of smaller or larger nerve-branches, which supply a given tissue complex.

Conduction-anæsthesia represents the completest stage of local anæsthesia, for by anæsthetizing a branch of a nerve with a comparatively small amount of anæsthetic agent, the loss of sensitiveness of a greater or lesser region of the body may be induced. Notwithstanding this fact, infiltration-anæsthesia cannot, as we shall see, be dispensed with. By combining both procedures we often obtain more complete and more certain anæsthesia than when we employ conduction-anæsthesia alone.

In bringing about conduction-anæsthesia there is a considerable difference in whether the solution be injected directly into the nerve, "endoneural injection," or into the tissues surrounding the nerve, "perineural injection." The former method was that more particularly practised by Crile, who exposed the nerve before injecting under the nerve-sheath. Anæsthesia was induced immediately in such cases, and extended to the entire thickness of the nerve. Crile's procedure was too cumbersome, and necessitated a more or less extensive preliminary operation consisting in the preparation of the nerve, and this in itself already meant operative interference. The method therefore found but few adherents. Nowadays we try to attain the same goal by the percutaneous endoneural injection, having previously determined the course of the branches of the nerves with anatomical accuracy, and secured certain guides in the form of bones and soft tissues, which facilitate the carrying out of the injection.

Nevertheless, endoneural injection, which is the ideal form of conduction-anæsthesia, will only succeed in a few cases, and we must rest satisfied if we succeed in injecting the anæsthetic into the neighbourhood of the nerve, and by diffusion of the solution into the nerve obtain insensitiveness of the latter. The time intervening between the introduction of the anæsthetic and its permeating into the nerve and manifesting its activity is longer when this perineural method is employed than in the case of the endoneural. The thicker the nerve is, the longer will we have to wait, naturally.

Only quite recently has it been possible to employ the perineural method of anæsthetization with success. In the first place, it was necessary that larger quantities of the anæsthetizing agent should be applicable as well as higher concentrations without any risk being run of toxic effects being produced ; and secondly, ways and means had to be found to prevent premature absorption of the solution. All these conditions were only fulfilled recently, the result being that the employment of perineural injection has been greatly stimulated.

The most peripheral form of interruption of conduction consists in subcutaneous infiltration, in which the very finest nerve-branches distributed to the skin are rendered insensitive by being bathed in the anæsthetizing solution. The more proximally the nerve is struck the thicker will be its sheath and hence the slower and the more uncertain will be the action of the anæsthetic. The most central type of interruption of conduction is that known as lumbar anæsthesia ; here again the anæsthetizing agent is able to act with greater intensity owing to the absence of nerve-sheaths.

An important advance from a practical point of view accrued to conduction-anæsthesia by the introduction of Hackenbruch's "circular analgesia," which consists in anæsthetizing the field of operation by injecting all round it, thereby interrupting the conduction of all the afferent nerves. For this purpose, Hackenbruch employed solutions containing from 0·25 to 0·5 per cent. of cocaine or eucaine.

As we have already mentioned, Hall and Halstedt were the first to produce interruption of nerve conduction in the large nerve-trunks. The former produced anæsthesia of the infra-orbital nerve, the latter of the inferior alveolar nerve, for the purpose of dental extraction from the lower jaw. Oberst used the same method in 1888 on fingers and toes, injecting 0·5 to 1 per cent. solutions of cocaine subcutaneously round the base of the first phalanges and simultaneously constricting the corresponding limb. In 1890 the same method was described by Pernice ; and Braun and Hackenbruch again drew attention to its excellence in 1897.

By the employment of the practically non-toxic novocain for local anæsthesia and adding suprarenin, introduced by Braun, conduction-anæsthesia has made great advances and its range of applicability has been increased within recent years. There is hardly any large nerve-trunk that cannot be reached by the needle used in this type of anæsthesia. We have thus witnessed a rapid and consecutive extension of the application of this method in the form of anæsthetization of the branches of the trigeminal nerve (Braun), of the Gasserian ganglion (Haertel), of the brachial plexus (Hirschel, Kulenkampff), of the main nerve-trunks of the lower limbs (Laewen, Jassenetzki-Woino, Keppler).

This further development of the anæsthetization of the great

conducting nerves has been accompanied by a proportional increase in the difficulty of the technique and it often depends on the personal dexterity and experience of the anæsthetist whether the desired results are obtained or not.

In consequence of this rapid progress in the field of local anæsthesia and the good results obtained, the number of cases in which general anæsthesia is used has decreased considerably, whilst that of cases in which local anæsthesia is employed has proportionately increased enormously.

In the Heidelberg surgical clinic during 1906, 85 per cent. of the operations were performed under general anæsthesia, and 11·4 per cent. under local; in 1911 the numbers were respectively 52 per cent. and 42 per cent. (this refers to in-patients only). In 1910 Braun performed 40·1 per cent. of his operations under local anæsthesia. In the Marburg clinic the numbers reached as much as 55 per cent., and Hackenbruch reports 50 to 68 per cent.

For some time the domain of local anæsthesia has no longer been restricted to minor surgery; even the most extensive operative interferences no longer offer any difficulties as regards the successful induction of this form of anæsthesia. As a consequence of the reduction of the risks attached to the latter, the results of operations have improved considerably. We need only mention operations on the skull and face, extensive operations on the thorax, prostatectomies and amputations. The advantage of the fact that no assistant is necessary for the anæsthetic is also by no means to be underrated.

Indications and Contra-indications for Local Anæsthesia.

Notwithstanding these great and evident advantages accruing to local anæsthesia we must not forget that there are also certain direct contra-indications to its employment.

In the case of children, general narcosis will not be avoidable in the majority of cases, but even among these there are exceptions, and some intelligent children permit of local anæsthesia being employed. Naturally, it also depends on the extent of the operation.

But even among adults the greater percentage have to be excluded from local anæsthesia. Excitable and timid patients should not be anæsthetized by this method; prolonged consequent nerve shock may lead to unpleasant complications. On the other hand, there are a certain number of patients who will only consent to an operation if it be performed without a general anæsthetic. This undoubtedly

depends in part on the varying sensitiveness to pain manifested by the inhabitants of different districts.

The employment of local anæsthesia should not impede the radical extirpation of a tumour. If one notices before the operation that the extent of the field of operation does not permit of satisfactory local anæsthesia being induced, as is the case especially in malignant tumours, general narcosis should be preferred. On the other hand, it is possible to repeat the injection of the solution, if required, after the operation has been commenced.

There are thus several factors to be considered with regard to the indications or otherwise for the employment of local anæsthesia in each particular case, and a little experience will usually enable one to decide upon the right course to pursue.

Preparation of the Patient for Local Anæsthesia.

Closely connected with the position taken by the anæsthetist as regards the advisability of local anæsthesia is the preparation of the patient for its induction.

This is in so far of importance, as some patients are more readily persuaded to consent to an operation without general narcosis, if some sedative be previously administered. The terrors of the operating room and the bad impression which the patient receives owing to everything connected with an operation are removed or at least considerably diminished if a mild narcotic be administered. Unless there be some special contra-indication, it is advisable to administer a small dose of morphia (0·01 to 0·02 grm. = $\frac{1}{6}$ to $\frac{1}{3}$ gr.), before each local anæsthetization. Pantopon will serve the same purpose. On the evening preceding the operation much may be done to calm the patient by administering some soporific (veronal, codeonal, &c.). By so doing the patient's psyche is sufficiently blunted to external influences to prevent the operation leading to any further excitement.

In some cases it may be advisable to inject scopolamine, but it is not advisable to make this an invariable rule before every local anæsthesia, since the administration of this not always quite harmless drug is, as a rule, superfluous. Some operators are in the habit of administering such large doses of scopolamine and morphia before inducing local anæsthesia or lumbar anæsthesia, that the former would in themselves suffice to render the patient insensitive to the operation. Braun administers in isolated cases 0·0005 to 0·001 grm.

of scopolamine ($\frac{3}{400}$ to $\frac{3}{200}$ gr.) and 0·01 to 0·015 grm. of morphia ($\frac{1}{6}$ to $\frac{1}{4}$ gr.) from one to one and a half hours before the operation previous to inducing local anæsthesia. Hohmeier recommends that 0·5 to 1 grm. of veronal ($7\frac{1}{2}$ to 15 gr.) should be given the evening before, and 0·01 to 0·02 grm. of morphia ($\frac{1}{6}$ to $\frac{1}{3}$ gr.) half an hour before local anæsthesia is induced.

The latter procedure is decidedly that most to be recommended, scopolamine being only employed in isolated cases.

Any further preparation of the patient previous to the induction of local anæsthesia is not requisite. All aseptic and antiseptic precautions should be strictly enforced, of course, just as they are for an operation.

Drugs used for Local Anæsthesia.

As we have already emphasized, the great advance in the employment of local anæsthesia has been due in a by no means small degree to the almost general introduction of novocain.

Relatively non-toxic substances, such as eucaine, alypin, akoin, tropacocaine, holocaine, nervanine, stovaine, aneson, &c., had been previously discovered, but it was the discovery of novocain that placed in our hands the ideal drug for local anæsthesia. It satisfies all the demands which Braun postulates for a local anæsthetic, namely, that the latter should be less toxic than cocaine proportionately to its local anæsthetizing power, that it should not cause any damage to the tissues, that it should be soluble in water and easy to sterilize when in solution, and finally, that it should be capable of being combined with some adrenal preparation.

Novocain satisfies every one of these conditions. It was first obtained by Einhorn in 1905, and is produced commercially by the firm of Farbwerke, Hoechst. It is a white powder readily soluble in water. The solutions can be heated to 120° C. without decomposition setting in. The dose employed may be considerable without any toxic effects being produced. Single doses of 0·5 to 1 and 1·5 grm. ($7\frac{1}{2}$, 15 and $22\frac{1}{2}$ gr.) have been administered without any unpleasant symptoms resulting.

The fatal dose of novocain for rabbits is 0·73 grm. per kilogram body-weight, when subcutaneously injected as a 10 per cent. solution.

The toxicity of novocain is seven times less than that of cocaine, and one-third of that of the other substitutes. When very high doses have been administered, clonic-tonic spasms and opisthotonus, restlessness and acceleration of the respiration have been observed. Vomiting is not a rare occurrence after the administration, by injection,

of novocain, but it is quite free from significance. Some patients seem to be particularly intolerant to novocain, even in small doses, whilst others again will bear large doses without the slighest unpleasant symptoms supervening.

Laewen and Braun observed toxic symptoms in a case in which 20 to 25 c.c. of a 2 per cent. solution of novocain had been injected into the sacral canal ; the symptoms were, feeling of nausea, sweating, pallor, small pulse, accelerated respiration, feeling of oppression and vomiting. The author has also met with severe collapse in one case after the injection of a like dose into the sacral canal. Krecke purposely injected 2 c.c. of a 20 per cent. solution of novocain subcutaneously, but could observe no untoward symptoms. Fischer reports the case of a healthy lady, aged 36, who became semi-comatose after the injection of 3 c.c. of a 2 per cent. solution of novocain-thymol for the extraction of the gangrenous root of a molar ; she only recovered from this condition twenty minutes later, when the extraction of the root caused slight pain. Fischer explains this case as one of hynoptic sleep induced by the administration of the novocain.

Liebl experimented on himself to test the toxic effects of novocain. After injecting 0·75 grm. of a 10 per cent. solution into his thigh, he felt a sudden warmth in the whole body, especially in the hepatic region, nausea, inclination to vomit, and general restlessness. Two minutes later slight deafness occurred in his left ear, further there was some disturbance of vision, double vision being produced, and accommodation being difficult in both eyes, thirteen minutes after the injection headache supervened, and somewhat later paræsthesia in the radial region. After about half-an-hour the symptoms had disappeared.

Hysterical attacks have also been observed after the administration of novocain. Balzer reports one fatal case after the injection of 3 c.c. of a 2 per cent. solution of novocain-suprarenin for the purpose of dental extraction. After initial symptoms of giddiness and malaise, unconsciousness and death, accompanied by signs of cardiac weakness, supervened eight hours after the injection had been administered. Fischer ascribes this case to acute sepsis ; in any case it seems very unlikely that the fatal result was due to the injection of so small an amount of novocain. Unfortunately no *post-mortem* examination took place.

Notwithstanding these isolated accidents and the transient disturbances produced by novocain injections, we must regard the drug as an anæsthetic that can be administered without risk to the patient even when larger doses are employed. It must be remembered, however, that patients often respond very differently to the drug, and that there may be some in whom there is a definite idiosyncrasy.

The most commonly employed solutions of novocain are those

containing 0·5, 1, or 2 per cent.; the two former are, as a rule, sufficient, but in inducing conduction-anæsthesia in thick nerve-trunks, 2 to 3 or even 4 per cent. solutions have been employed.

Braun, as a rule, uses the 0·5 per cent. solution, and in the case of conduction-anæsthesia, 1 to 2 per cent. solutions. Hohmeier likewise uses 0·5 per cent. solutions. The solutions employed at the Heidelberg clinic are of 1 to 2 per cent. concentration. The most common form of preparing the solutions is by using the tablets prepared according to Braun's prescription by the Hoechst Farbwerke. Novocain-suprarenin tablets A, consisting of 0·125 grm. novocain, and 0·00012 synthetical suprarenin are used. The solution should be prepared immediately before use. Braun describes his method of procedure as follows :—

"One to two to four tablets, dissolved in 25 c.c. of sterile physiological salt solution give 0·5 to 1 to 2 per cent. solutions respectively. The tablets required for an operation are placed in a sterile metal box or a sterile test-tube, a little of the above-mentioned acidulated salt solution is poured on to them and they are dissolved by rapid boiling over a spirit lamp. The solution is then poured into a sterile porcelain measure and diluted to the extent desired by adding ordinary sterile physiological salt solution. The solution should be taken direct from the measure when being used."

The acidulated salt solution is added by Braun in order that the suprarenin contained in the tablets may not be decomposed by the boiling, and thus rendered useless and inert. As soon as suprarenin contains a small amount of hydrochloric acid it can be sterilized by boiling. Braun therefore recommends that a small amount of hydrochloric acid, about three drops of acidum hydrochloricum dilutum, should be added to each litre of the physiological salt solution used for dissolving tablets containing suprarenin.

The suprarenin most commonly used comes from the Hoechst Farbwerke and can be procured either as an organic preparation or as a synthetic product. The solution, containing 1 in 1,000, sold has a little hydrochloric acid added to render it more durable. Notwithstanding this the suprarenin does not keep well. For this reason suprarenin tablets are also manufactured; for in the dry state suprarenin remains unchanged for a considerable time. These tablets contain 1 mg. of suprarenin.

The English adrenalin and paranephrin manufactured by Merck are also much used. The latter is preferred by Hackenbruch, as his experience has taught him that paranephrin exerts a better vaso-constricting action than synthetically produced suprarenin.

The suprarenal preparation introduced by Braun for the purposes of conduction-anæsthesia has proved of great value. It has the specific property of contracting the walls of the capillaries and smaller

vessels. This leads to the absorption of the injected solution being retarded so that it is retained longer at the site of injection and can act with greater intensity on the nerves, a local anæmia being at the same time produced which permits of a better view of the field of operation being obtained. These advantages are so great as to have become almost indispensable.

The great development which has occurred in local anæsthesia is in the main based on this valuable discovery of Braun's. Suprarenin is capable of acting even when diluted to 1 in 10,000; it is highly toxic, and more than 0·5 mg. should not be injected as a single dose.

The tablets introduced by Braun and mentioned in the above are manufactured by several firms, among them being Farbwerke, Hoechst, and G. Pohl in Schoenbaum, near Dantzig; they contain novocain with added suprarenin.

These tablets are sent into commerce ostensibly in a sterile condition, so that they can be directly used after being dissolved in salt solution. This form of employment was the one commonly used formerly, and infection practically never occurred. Braun and Hohmeier never experienced any such accidental infections, and in the surgical clinic at Heidelberg, in which these tablets were extensively employed formerly, no infections could ever be traced to their use.

Hoffmann and Kutscher have proved the presence of bacteria in a considerable number of these tablets, hence the possibility of infection occurring at some time or other is not absolutely excluded. It is for this reason advisable to sterilize the novocain solution before use, and this can be done without any risk of damaging the preparation. In order to avoid decomposition by boiling of the added suprarenin in the tablet Braun advises, as we have already mentioned, that the salt solution employed for dissolving the tablets should be acidulated by the addition of a few drops of hydrochloric acid (three drops to the litre). The suprarenin is then no longer likely to become decomposed. We have already described the method of procedure recommended by Braun for the preparation of the solution. It is most simple and satisfies all the demands of asepsis. The disadvantage of the slight loss of time entailed by the boiling of the solution before each operation can hardly be regarded as of any significance.

Hackenbruch prepares his solutions in a like manner. He lets the operating theatre sister weigh out 0·5 grm. of the novocain powder, of which he keeps a large supply in stock, and dissolve it in 100 c.c. of physiological salt solution. Having added fifty drops of paranephrin she places the whole into a water-bath and boils it for a few minutes, after which the 0·5 per cent. solution is ready for use.

In larger surgical institutions in which larger quantities of the anæsthetic are used daily the solutions of novocain may be kept in

stock, the suprarenin being added subsequently before each anæsthetization.

At the Heidelberg clinic the 1 to 2 per cent. novocain solutions are sterilized in strong glass bottles and placed ready for use in the operating room every morning. These solutions are absolutely sterile (fig. 1).

When the solution has to be used the required quantity is taken direct from the bottle, the requisite amount of suprarenin being added drop-wise from the original bottle supplied by the Hoechst firm. So far the suprarenin solution has invariably been found to be sterile. The results of cultural experiments were always negative, and clinically no infections have as yet ever been traceable to the injections.

FIG. 1.

Axhausen recommends a 2 per cent. or 4 per cent. solution of novocain, which should be sterilized in glass flasks closed by cotton-wool plugs and kept in stock. The suprarenin is used in the form of tablets containing 1 mg. of the drug, this is boiled in acidulated salt solution and then added to the novocain solution.

There are, therefore, various methods that may be utilized in preparing an unexceptionable anæsthetic containing novocain and suprarenin at short notice.

The most convenient form is that recommended by Braun. This is more especially the case where the amount of operating is limited, and for the general practitioner. The latter can rapidly prepare a sterile anæsthetic solution ready for use by dissolving the tablet in physiological salt solution, and, if necessary, boiling it after adding a little hydrochloric acid.

It is a noteworthy fact that Gros found by experiment that in animals novocain-bicarbonate solutions were five times as powerful in their anæsthetic properties as the corresponding novocain-hydrochloric solutions.

Laewen tested these results in man, and found that the former solution produced more rapid and more enduring anæsthesia. He recommended the novocain-bicarbonate solution more especially for extradural anæsthesia.

Hoffmann and Kochmann made further experiments with a view to increasing the anæsthetizing power of novocain by the addition of various substances. They combined the novocain with potassium sulphate, and noticed that by so doing the concentration of novocain could be lowered considerably below the arithmetic mean.

A 0·1 per cent. solution of novocain-potassium suprarenin corresponded to the ordinary 0·5 per cent. novocain solution as regards its efficacy. A further advantage, according to these authors, is that these solutions do not give rise to any after pain. The whole matter requires further investigation.

Instrumentarium.

In course of time several useful forms of syringe have been introduced for local anæsthesia. The main points required in such a syringe are: great durability, handiness, and facility in sterilization, and that it should be easily separated into its component parts. The most commonly used syringe is probably the "Record" syringe, consisting of glass and metal, and satisfying all the conditions required. There is certainly one drawback to it—the glass cylinder is apt to crack rather readily when boiled. Hammer therefore recommends a metal syringe into which the solution is poured from above by means of a metal vessel. This syringe possesses several advantages, but one drawback is that it is more cumbersome to use than the "Record" syringe, which can be filled by merely aspirating the solution, whilst the needle may be allowed to remain in the tissues.

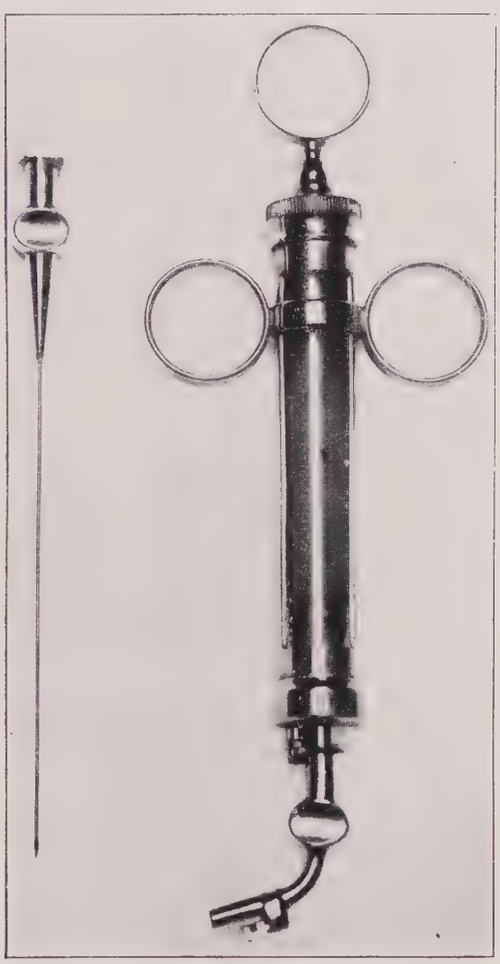

Fig. 2.

Hackenbruch recommends his own excellent syringe with bayonet fixation of the needle and nozzle attached at an angle.

Braun employs only straight needles, because he maintains that he can feel better with these than with curved ones. Hohmeier recommends platinum-iridium needles, which can be readily bent as required. For deep injections reaching the bones he employs steel needles.

At the Heidelberg surgical clinic a syringe is used,[1] which

[1] Obtainable from Friedrich Droell in Heidelberg.

resembles that devised by Hackenbruch, and has been found to answer the purpose excellently (fig. 2). It consists of glass and metal, the piston is ground so as to be airtight in the cylinder, and also consists of metal; it is connected with the piston-rod by a ball and socket joint, the advantage of which is that increased mobility is thereby attained, and the glass cylinder is not so liable to be broken if the direction of the piston should not exactly correspond with the longitudinal axis of the cylinder when the injection is being administered. At the nozzle end of the syringe there is an adjustable angular piece with hook attachment, a similar attachment being provided on the steel needle, which is 6 to 8 cm. long; so that by dispensing with the angular attachment, and fixing the needle directly to the nozzle, the injection can be made with a straight needle. The hook attachment has this advantage, the syringe can be removed for refilling whilst the needle is left embedded in the tissues.

When sterilizing the syringe it should be taken to pieces. Care should be taken to employ only pure water or salt-solution for sterilizing syringe, needles, dishes, and measures, &c., by boiling, for soda solutions would render the anæsthetizing fluids worthless. Braun has devised a movable table capable of holding all the objects required for local anæsthesia. It comprises a dish for the instruments (syringes and needles, &c.), a partition for the salt solution, one for carbolic acid lotion, a flask for the salt solution, a spirit lamp, &c., all combined in a most convenient manner.

B.—SPECIAL SECTION.

Local Anæsthesia in Cranial Operations.

(a) Operations on the Soft Parts.

The hairy scalp offers an excellent field for local anæsthesia. The reason for this is the favourable course run by the sensory nerves, which are situated directly under the skin and extend their long course from the frontal, temporal, and occipital regions towards the parietal regions, where they divide into branches. They supply the skin, the periosteum and the bones, so that all the layers of tissues except the cerebral membranes can be reached by means of subcutaneous injection and anæsthetized. These nerves are derived partly from the trigeminal nerve, partly from the cervical plexus. Fig. 3 shows their distribution. Whereas the frontal and temporal regions and the ear are supplied mainly by the trigeminal nerve, the sensory innervation of the occipital region is mainly derived from the cervical plexus. By subcutaneously injecting a weak solution of novocain below the hairy scalp above the eye-brows in the direction of the temples and at the level of the occipital protuberance, anæsthesia of the entire roof of the cranium may be induced. As a rule, however, so extensive a field of operation is not necessary and anæsthesia of a part only of the cranial roof suffices. Thus for the removal of small tumours like atheromata, carcinomata angiomata, &c., it is best to anæsthetize a so-called Hackenbruch's rhombus, that is to say, to start with two infiltration wheals, and from them inject the solution subcutaneously round the tumour in diverging directions. In the case of larger tumours more points of injection may be required.

The interruption of the conduction of one or other of the nerve-trunks mentioned above as supplying the cranium is easily carried out. If the field of operation be situated more in the occipital region, for instance, in the area of distribution of the N. occipitalis major, both large occipital nerves can be put out of action by means of a transverse line of subcutaneous injection below the occipital protuberance, whereby, as will be seen by comparing fig. 4, a large zone of anæsthesia is obtained. By extending the line of injection laterally in

FIG. 3.—The Nerves of the Face. (Spalteholz.) *a*, N. Supra-orbitalis. *b*, Ramus zygomatico-temporalis (trigeminus II). *c*, Ramus frontalis n. frontalis. *d*, N. supra-trochlearis. *e*, N. infra-trochlearis. *f*, Ramus nasalis exterior. *g*, Rami n. infra-orbitalis. *h*, N. auricularis magnus. *i*, N. facialis. *j*, N. auriculo-temporalis. *k*, N. auricularis post. *l*, Nn. auriculares ant. *m*, Rami temporales superficiales. *n*, Nn. occipitales major and minor.

both directions into the region of the mastoid process the sensory areas of the small occipitals may be anæsthetized also.

In a manner analogous to that just described for anæsthetizing the occipital region the frontal region and a part of the hairy scalp may be anæsthetized by a sub-fascial injection which extends in one line from one outer canthus across the top of the eyebrows and the

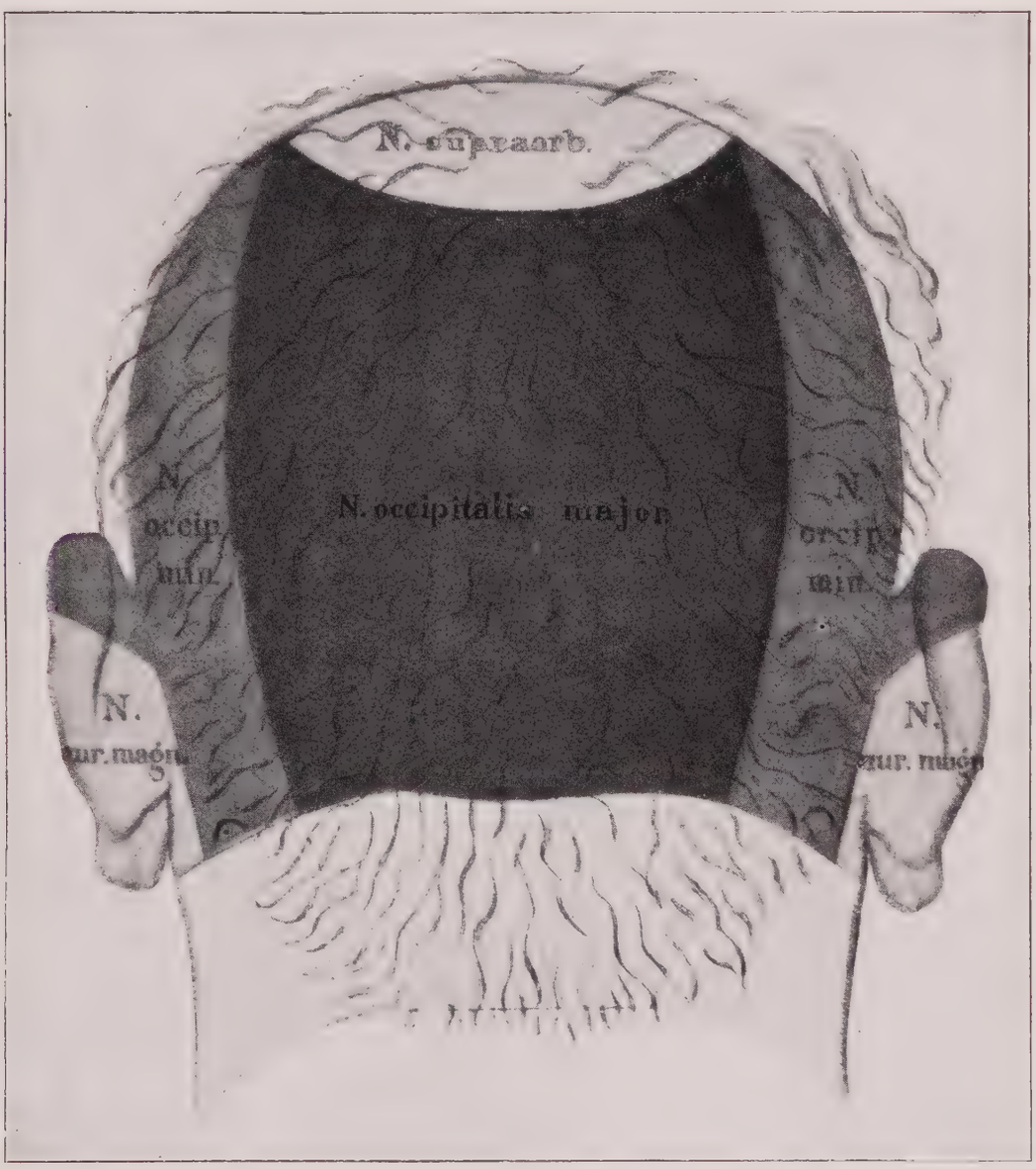

FIG. 4.—Sensory innervation of the occipital region. (Hasse.)

bridge of the nose to the other outer canthus. The direction of this injection and the region in which anæsthesia is thereby obtained, and which affects the supra-orbital and frontal nerves is shown in fig. 5.

(b) Operations on the Bones of the Skull.

Since the sensory nerves that innervate the cranium run a subcutaneous or sub-fascial course to so great an extent and in so favourable a manner, and supply all the layers of tissues, including the

bones, it is also possible to operate on the bones of the skull under complete local anæsthesia. Trephining of the skull is rarely performed under general anæsthesia nowadays; only in the case of children or highly nervous individuals will this be unavoidable. The administration of a full dose of morphia with or without scopolamine is particularly advisable before trephining operations, partly in order

FIG. 5.—Line of injection and anæsthetic area for the supra-orbital and frontal nerves.

to calm the patient before the operation, but still more so to reduce the unpleasant sensation of shock which occurs when the skull-cap is opened.

These **trephining operations** under local anæsthesia have been performed by many surgeons for several years. They are described in detail by Braun, among others. Braun attaches particular

importance to the addition of suprarenin to the novocain in trephining operations because the hæmorrhage is greatly reduced by it, and hæmorrhage often causes a considerable amount of trouble in these operations, the whole field of operation being flooded with blood in a most inconvenient manner. Those who employ "suprarenin-

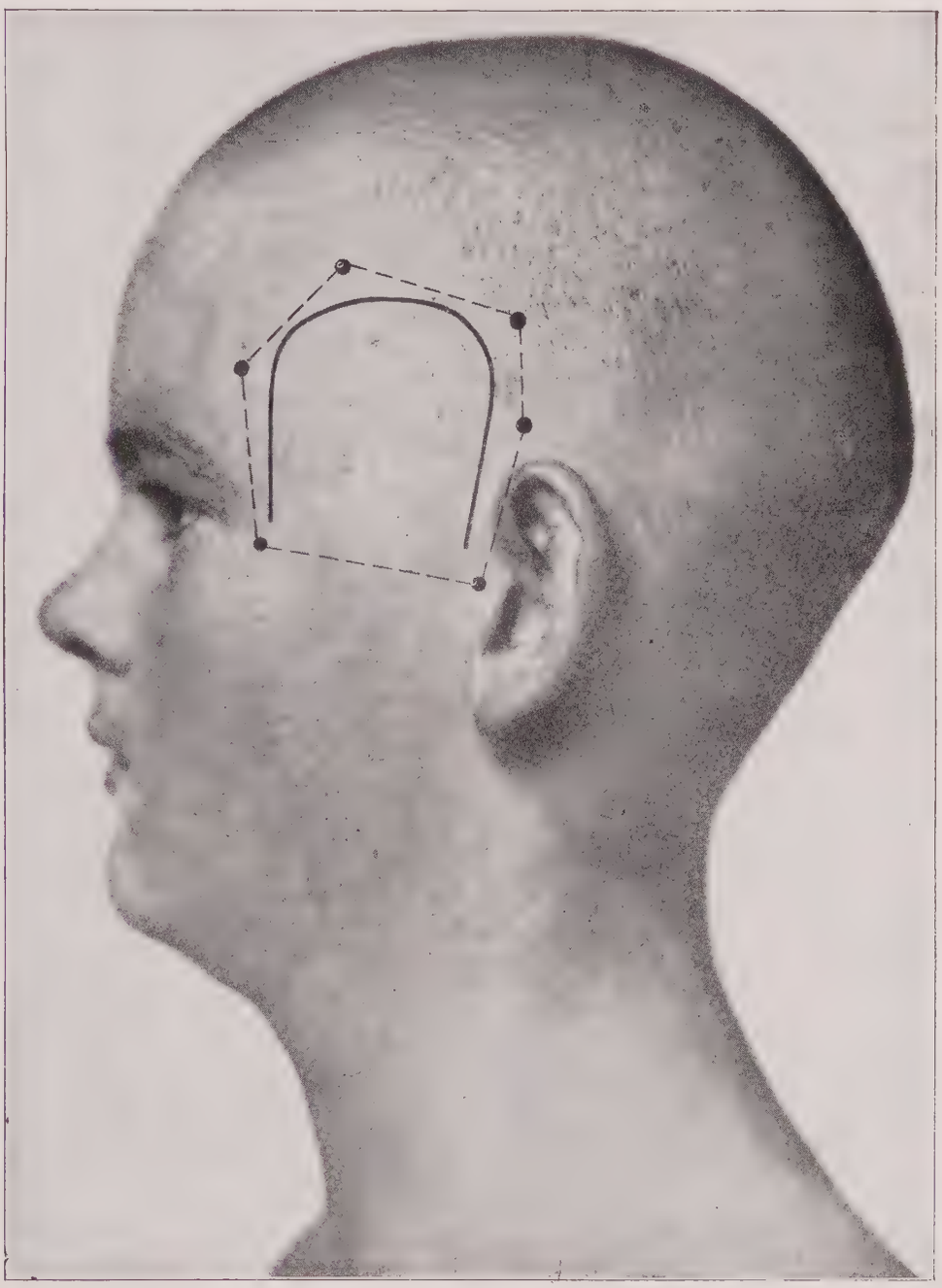

FIG. 6.—Trephining in the temporal region.

anæmia" in performing trephining operations will soon notice that Braun is perfectly right in attaching so much importance to it. Braun also recommends it in cases where trephining and laminectomy are performed under a general anæsthetic and considers circum-ligaturing according to Heidenhain's method, or the use of metal plates as recommended by Kredel, as well as the clamping of the edges of the

wounds with spring-clamps according to Vorschuetz's method to be superfluous.

In the trephining operations performed by Wilms under local anæsthesia almost complete bloodlessness is always procured by a combination of suprarenin-anæmia and Heidenhain's circum-ligaturing, whereby the operation is much facilitated.

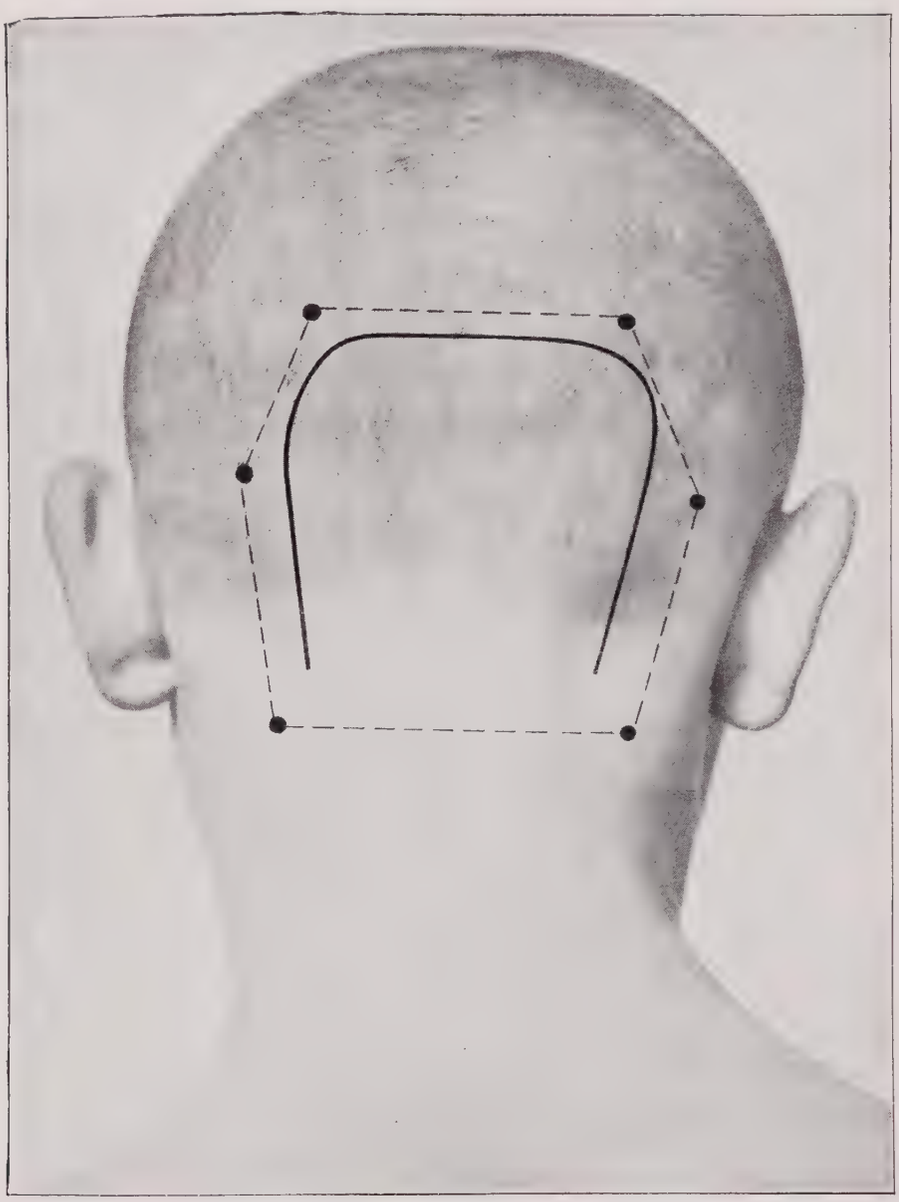

FIG. 7.—Trephining in the occipital region.

Any part of the skull may be satisfactorily trephined under local anæsthesia. Two typical cases may be given as instances with a description of the technique.

Fig. 6 shows the incision for one of the most common trephining operations in the temporal region. From the individual points which may be indicated by wheals, the 0·5 to 1 per cent. solution of novocain and suprarenin is injected subcutaneously or sub-fascially down as far as the periosteum in the direction of the dotted lines that

unite the points. The quantity of novocain-suprarenin solution used need not exceed 50 to 60 c.c. From the two points at the base of the bone-flap above the zygomatic arch the layer of soft parts including muscles right down to the periosteum must be permeated by the solution.

The malar bone can also be temporarily resected, so that extirpation of the Gasserian ganglion may also be carried out under local anæsthesia (Krause).

The field of operation in trephining should be injected in such a manner that the zone of anæsthesia sufficiently overlaps that of incision in all directions, so that the operation should not be impeded at any stage. In fig. 6 a curved incision is shown.

Another typical trephining operation which lays bare one or both cerebellar hemispheres, and also forms a good subject for local anæsthesia, is shown in fig. 7.

The points of insertion of the needle are marked by wheals in an analogous manner to that described above, and then united by subcutaneous injection by means of a long needle. These lines of junction are shown in the figure as dotted lines. Whilst it is sufficient to permeate the subcutaneous tissues near the upper points, from the two basal points which are situated close to the mastoid processes the neck muscles must be infiltrated with the anæsthetic, and then the deeper tissues right down to the periosteum of the tabular part of the occipital bone and the transverse processes of the cervical vertebræ should be infiltrated; 100 c.c. of the novocain-suprarenin solution should suffice for the entire procedure. In this case also the addition of suprarenin is of great value, the bleeding from the neck muscles being very slight.

Local Anæsthesia in Operations on the Face.

In operating on the face until quite recently one had to be satisfied with infiltration-anæsthesia. This method had also attained a high state of perfection owing to Braun's publications, so that extensive operations on the face could be carried out under total infiltration-anæsthesia of the tissues. Only a few conduction-anæsthesias were possible, and these were in the main induced at the points of exit of the three main branches of the trigeminal nerve, the supra- and infra-orbital nerves, the mental nerve, and also the mandibular and the posterior superior alveolar nerves. The conduction of the lingual nerve could also be interrupted even at that time.

By the aid of these possibilities of anæsthesia a large number of face and dental operations could be performed without having recourse to general narcosis. Only the deeper parts of the head and the deeply situated bones, such as the upper jaw, &c., were still unattainable to local anæsthesia. The further evolution of conduction-anæsthesia, that is, the interruption of the conduction of larger nerve-trunks, and the recognition of the fact that by means of delicate needles which are caused to penetrate into the deep tissues no considerable or serious injury can be done to the vessels, have led to an advance in the use of local anæsthesia in the domain of surgery of the head such as had not been conceived possible.

The interruption of the conduction along the individual main branches of the trigeminal nerve, and even at the Gasserian ganglion have developed into a method which renders it possible for us to perform the most severe and most difficult operations in the region supplied by the trigeminal nerve without having recourse to general anæsthesia.

He who is cognisant of the difficulties and dangers attached to general anæsthesia in the greater operations in the region of the soft parts surrounding the upper jaws, and on the bones of the latter, for instance, will realize what it means to be able to perform such operations under local anæsthesia alone. Most of the patients on whom these operations were performed used to die as the result of aspiration or pneumonia; these dangers were all the greater, as the cases usually consisted of old people suffering from tumours of the upper or lower jaws. The dangers of severe hæmorrhage such as usually accompanies these severe operations and threatens the patient, often leading to serious consequences, cannot be under-estimated. This danger has also been practically removed by the addition of suprarenin to the injected solution.

If, as has already been emphasized several times, an adequate dose of morphia or pantopon or scopolamine be necessary in all severer operations performed under local anæsthesia, such a procedure is, above all, indicated in the case of operations in the region of the jaws, for here the psyche of the patient has to be considered to an even greater degree.

(a) The Anæsthetizing of the Individual Branches of the Trigeminal Nerve and the Gasserian Ganglion.

The evolution and development of this important and beneficent form of anæsthesia is based on the attempts made with alcohol injections into the trigeminal branches and in part also into the Gasserian ganglion in cases of neuralgia as performed by Schloesser, Ostwalt, Wright, Bodine and Keller.

These experiments were the foundation for the production of local anæsthesia in the area of distribution of the trigeminal nerve and for the deep injections into the individual main branches of that nerve at the base of the skull right up to and into the Gasserian ganglion. It was particularly Braun, Peuckert, Offerhaus and Haertel who converted this valuable form of local anæsthesia into a definite method; but others also were doing good work simultaneously in this field, and the author at that time published the results of a few successful trigeminus anæsthesias emanating from the Heidelberg surgical clinic.

More recently Haertel in particular has published extensive experiences in this special field, and to him is due the merit of having brought the Gasserian ganglion within reach of local anæsthesia.

If it could be stated that local anæsthesia had become a special department owing to the enormous extension it had received in recent times, a special procedure requiring a certain amount of practice if it was to be satisfactorily carried out, this dignity may be claimed still more now that anæsthetizing the trigeminal nerve and the Gasserian ganglion has become as it were a special department within the special department of local anæsthesia. Without dexterity and experience anæsthesia of this kind cannot be induced with certainty and without risk. A thorough knowledge of the course of the branches of the trigeminal nerve and their distribution to the various head areas is absolutely essential. When inducing this anæsthesia it is almost indispensable to have a good model or a skull at hand on which the direction of the needle and the depth to which it should be introduced may be carefully determined.

1.—THE ANATOMY OF THE TRIGEMINAL NERVE.

Figs. 8 and 9 will give an idea of the area of distribution of the main branches of the trigeminal nerve.

Whereas the first main branch, the ophthalmic nerve, supplies the sensory innervation of the forehead, the upper eye-lid and the dorsum of the nose, the second, the maxillary nerve, mainly supplies the upper jaw, and the third, the mandibular nerve, the lower jaw.

The three main branches of the trigeminal nerve start from the Gasserian ganglion, which in turn is formed by the expansion of the nerve-bundles of its sensory portion, the portio major, and is situated on the anterior surface of the pyramidal portion of the petrous bone embedded in a shallow depression covered by the dura mater; after leaving the Gasserian ganglion the branches diverge and emerge at the base of the skull.

The first branch (ramus ophthalmicus or trigeminus I) runs along

the lateral wall of the sinus cavernosus below the trochlear nerve and emerges through the superior orbital fissure.

Near the latter it divides into three main branches, the lachrymal, the frontal, and the naso-ciliary nerves.

The lachrymal is the most delicate of these branches, and mainly

FIG. 8.—Sensory areas of the head and neck. (Hasse.)

supplies the skin at the outer canthus, the conjunctiva of the lateral part of the upper eye-lid, and a part of the lower lid.

The thickest branch, the frontal nerve, continues the direction of the main stem under the orbital roof and above the levator palpebræ superioris muscle and divides into two branches, the supra-trochlear and the supra-orbital nerves (figs. 10 and 11). The former supplies the skin at the inner canthus and the conjunctiva of the medial end of the

upper lid; the latter supplies the skin of the upper lid, the forehead, and the scalp as far as the vertex, as well as the conjunctiva of the medial part of the upper lid, which it shares with the supra-trochlear nerve.

The third branch of the trigeminus I, the naso-ciliary nerve, turns

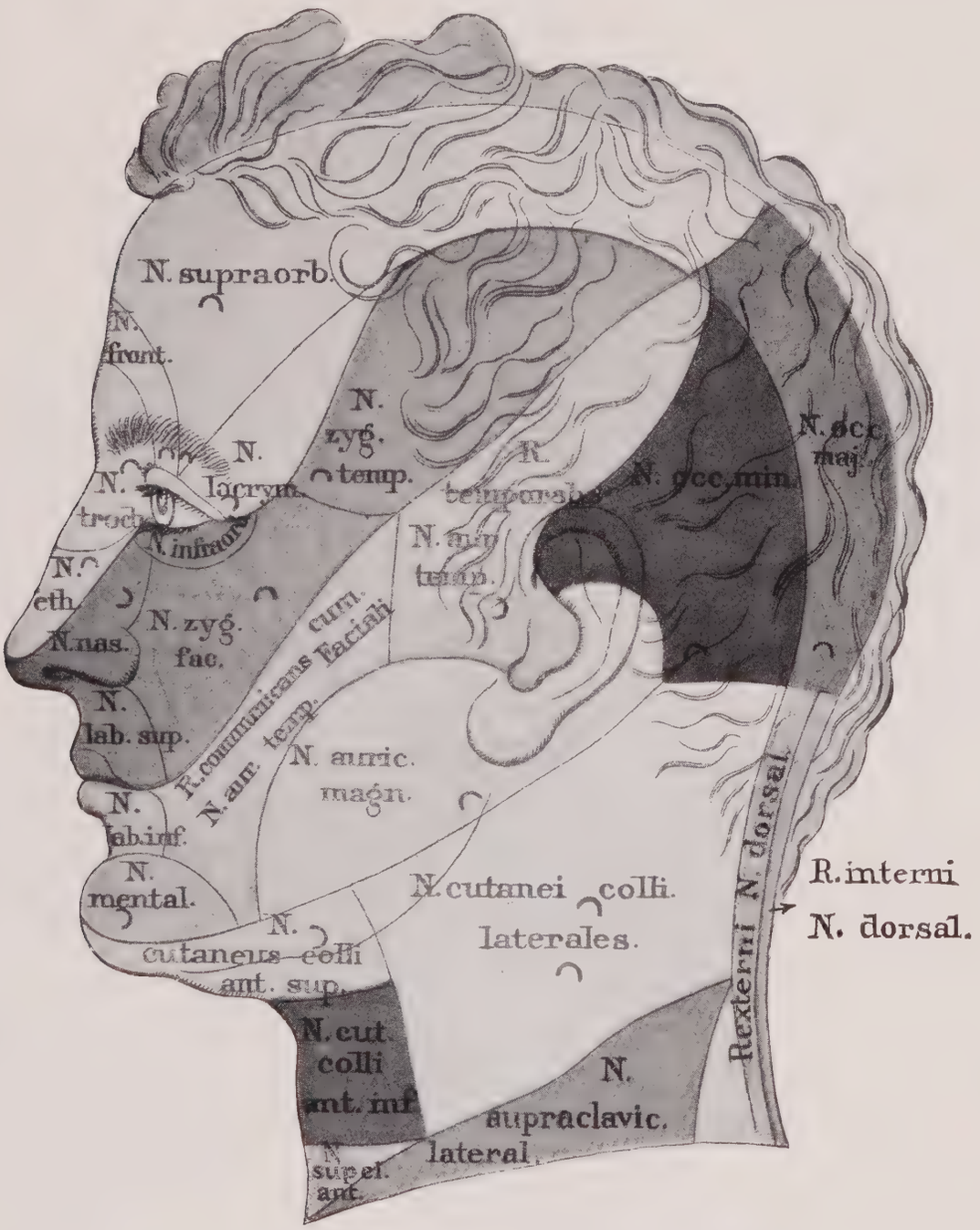

FIG. 9.—Sensory areas of the head and neck. (Hasse.)

off medially immediately above the optic nerve towards the orbital wall, passes through the anterior ethmoidal foramen and is distributed over the lamina cribrosa. It penetrates into the nasal cavity by one of the anterior ethmoidal perforations (the nasal fissure) and terminates on the mucous membrane and in the external skin of the nose. It supplies the tip of the nose, and, as the infra-trochlear nerve, the skin at the inner canthus of the eye, also the cornea, the conjunctiva of the

bulb, and the mucous membrane of the anterior superior part of the nasal cavity.

The trigeminus II, or ramus maxillaris, is thicker than the first and is purely sensory. Its course extends from the Gasserian ganglion through the foramen rotundum in the pterygo-palatine fossa, which

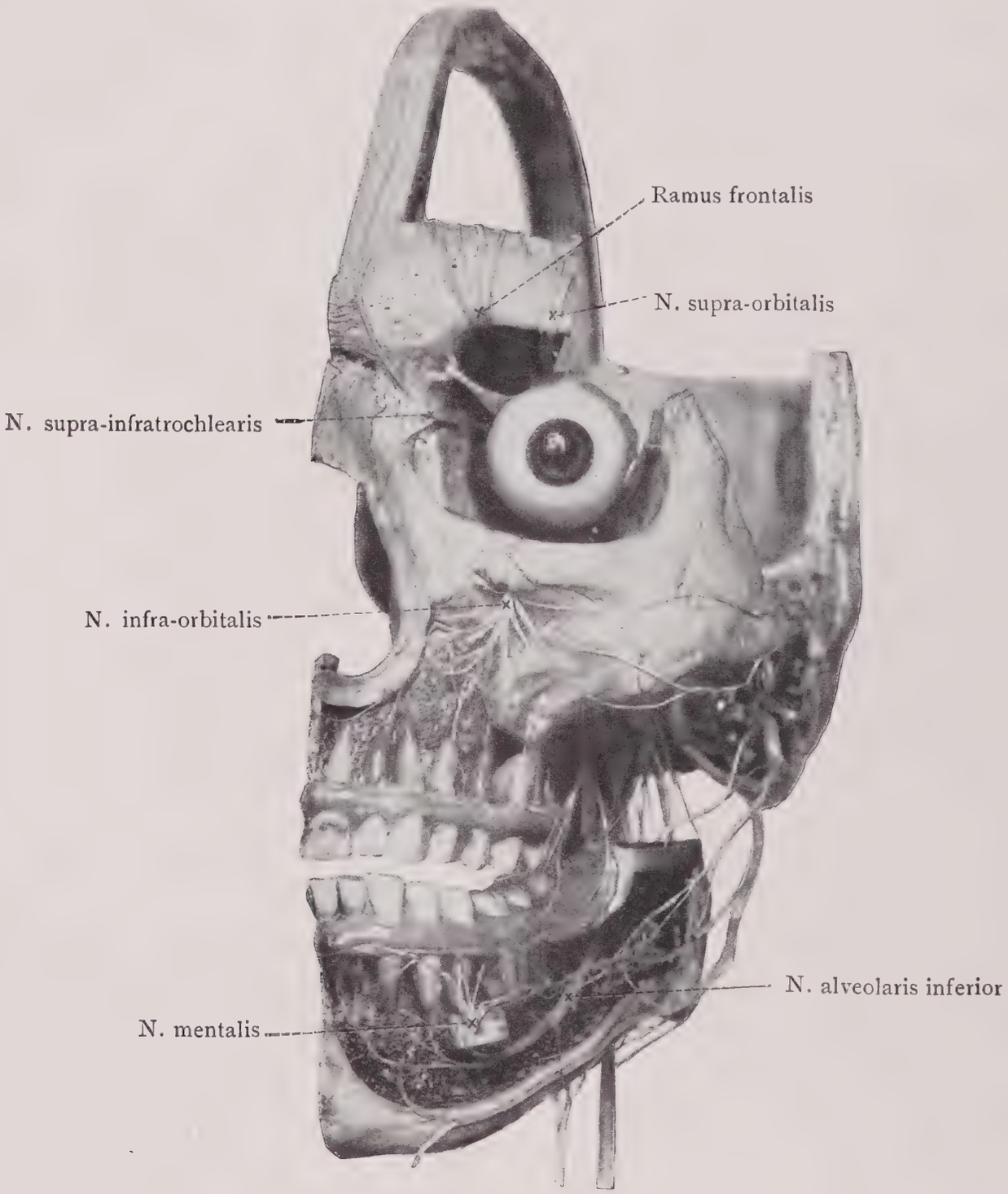

FIG. 10.—The branches of the trigeminal nerve from the front.

it traverses in the direction of the infra-orbital canal. From this canal it emerges as the infra-orbital through the foramen of the same name and spreads its terminal branches over the face (figs. 10 and 11).

Its most important branches are the zygomatic (orbital) and the infra-orbital nerves.

The former supplies, by its two branches, the zygomatico-temporal

(temporal) and the zygomatico-facial (malar) nerves, the skin of the anterior part of the temple, and the zygomatic region with sensory branches; the latter in addition the conjunctiva of the lateral part of the lower lid. By means of the second principal branch, the infra-orbital nerve, the skin of the ala of the nose, the lower lid and anterior part of the cheek and upper lip is supplied with sensory

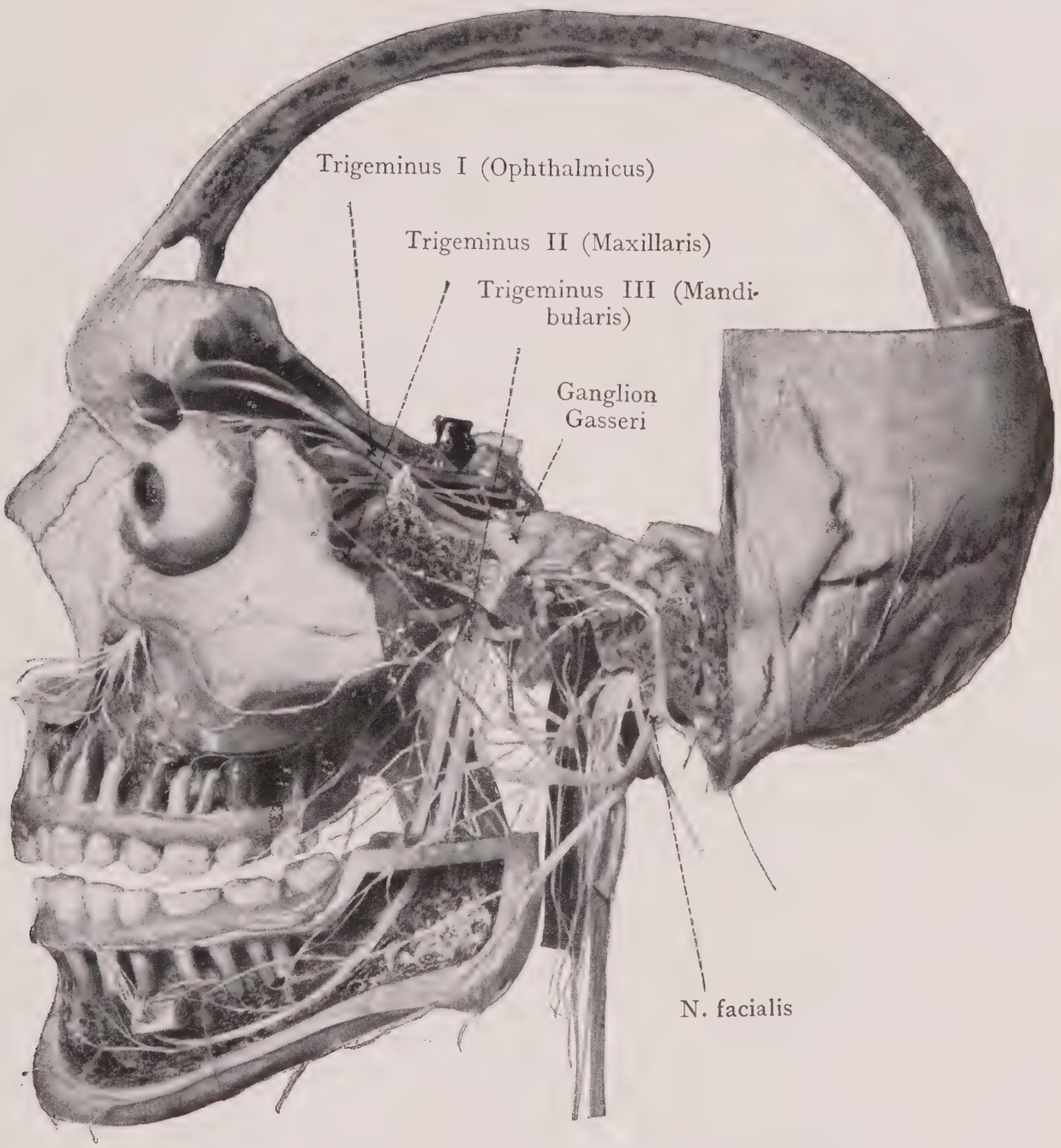

FIG. 11.—The branches of the trigeminal nerve from the side.

nerves, also a part of the conjunctiva of the lower lid and a part of the upper lid. One of the small terminal branches, the superior labial branch, goes to the mucous membrane of the upper lip.

A considerable portion of the infra-orbital nerve divides within the infra-orbital canal into branches, the Nn. alveolares superiores, which are distributed to and anastomose in the upper teeth and gums, and also send twigs to the mucous membrane of the antrum.

A third branch of the trigeminus II is represented by the spheno-palatine nerve which joins one of the sympathetic ganglia, the spheno-palatine ganglion. Sensory branches of this nerve supply the mucous membrane of the antrum of the superior maxilla, the hard and soft palate, the dental periosteum and gums of the upper jaw, also a part of the pharynx near the Eustachian tube, sharing this work with the glosso-pharyngeal nerve.

In anæsthetizing the teeth and gums, as we shall see more in detail later on, these two branches of the trigeminus II, the infra-orbital and the spheno-palatine, assume considerable importance.

Trigeminus III, or ramus mandibularis, is the thickest of the three main branches. It is composed of the third branch coming from the Gasserian ganglion and of the portio minor trigemini (or motor root). It leaves the cavity of the skull through the foramen ovale and contains both sensory and motor elements (fig. 11). The most important sensory branches are: the auriculo-temporal nerve, which supplies the skin of the anterior part of the auricle, of the temporal region and the cheek, also the external auditory meatus and a part of the outer surface of the tympanic membrane. A small branch of the trigeminus III, the buccinator (buccal) nerve, goes to the skin of the angle of the mouth and to the mucous membrane of the cheek.

There still remain the two terminal branches of the trigeminus III, the lingual and the mandibular nerves.

The former passes behind the external pterygoid muscle downwards to emerge between the latter and the internal pterygoid, and then turns obliquely downwards and forwards towards the floor of the mouth. It then crosses Wharton's duct and reaches the tongue medially, spreading out on the surface of the genioglossus into its terminal branches. It provides the sensory supply of the lingual gum of the front teeth, the tongue as far the foramen cæcum and a part of the tonsil.

The second large terminal branch of trigeminus III, the mandibular nerve, at first runs the same course as the lingual nerve and then through the mandibular foramen along the mandibular canal (fig. 11), to emerge at the mental foramen as the mental nerve (fig. 10), and supplies the skin of the lower lip and chin, as well as the mucous membrane of the lower lip, with sensory branches. In its course along the mandibular canal the inferior alveolar nerves branch off it and go to the lower teeth and gums. They are analogous in their distribution to the superior alveolar nerves.

From the following table by Haertel it is easy to obtain a survey of the sensory distribution of the individual branches of the trigeminal. In the case of the pharynx and larynx, the glosso-pharyngeal and vagus nerves have also been mentioned for the sake of completeness.

Main branch	Secondary branch	Sensory branch	Area of distribution
A.—Sensory innervation of the Skin by the Branches of the Trigeminal Nerve.			
I.—N. ophthalmicus	N. lachrymalis ...	... ...	Skin of lateral canthus.
	N. frontalis ...	N. supra-orbitalis...	Upper eyelid, forehead and crown.
		N. supra-trochlearis	Skin of medial canthus.
	N. naso-ciliaris ...	N. ethmoidalis ant. R. nasalis ext.	Tip of nose.
		N. infra-trochlearis	Skin of medial canthus.
II.—N. maxillaris	N. zygomaticus (orbital)	N. zygomatico-temporalis (temporal branch)	Anterior part of temple.
		N. zygomatico-facialis (malar branch)	Malar region.
	N. infra-orbitalis ...	... .	Ala of nose. Lower lid. Anterior part of cheek and upper lip.
III.—N. mandibularis	N. buccinatorius (buccal)	... ...	Skin at angle of mouth.
	N. auriculo-temporalis	... ...	Anterior part of auricle. Temple. Cheek.
	N. alveolaris inf.	N. mentalis ...	Lower jaw. Chin.
B.—Sensory innervation of the Mucous Membranes by Branches of the Trigeminal Nerve, as well as of the Glosso-pharyngeal and Vagus.			
I.—Conjunctiva and Bulb.			
I.—N. ophthalmicus	N. lachrymalis ...	... ...	Lateral part of upper lid. Part of lower lid (Zander).
	N. frontalis ...	N. supra-orbitalis N. supra-trochlearis	Medial part of upper lid.
	N. naso-ciliaris ...	N. infra-trochlearis	Medial part of lower lid and lachrymal sac.
		N. ciliaris and ganglion ciliare	Cornea, conjunctiva of bulb.
II.—N. maxillaris	N. infra-orbitalis ...	Rr. palpebrales ...	Lower lid, part of upper lid (Zander).
	N. zygomaticus (orbital)	N. zygomatico-facialis (malar)	Lateral part of lower lid
II.—Nose and Sinuses.			
(a) Nasal Cavity.			
I.—N. ophthalmicus	N. naso-ciliaris ...	N. ethmoidalis ant. (Nn. nasales ant.)	Anterior superior region of the nasal cavity.
III.—N. mandibularis	Nn. spheno-palatini Ggl. spheno-palatin.	Nn. nasales post., sup. and inf.	Rest of nasal cavity.
(b) Accessory Sinuses.			
I.—N. ophthalmicus	N. naso-ciliaris ...	N. ethmoidalis post.	Sphenoidal sinus and posterior ethmoidal cells.
	... ...	N. ethmoidalis ant.	Anterior ethmoidal cells. Frontal sinus.
II.—N. maxillaris	Nn. spheno-palatini N. infra-orbitalis ...	Rami nasales (Testut) Nn. alv. sup., post., med. and ant.	Antrum of Highmore.

Main branch	Secondary branch	Sensory branch	Area of distribution
III.—Cavity of the Mouth.			
II.—N. maxillaris	N. infra-orbitalis ...	N. alveolaris sup....	Upper teeth and gums on buccal side.
		R. labialis sup. ...	Mucous membrane of upper lip.
	Ggl. spheno-palatinum	N. nasopalatinus Nn. palatini	Palatinal dental periosteum and gums, hard and soft palate.
III.—N. mandibularis	N. alveolaris inf. ...	Rr. dentales ...	Lower teeth and gums.
		N. mentalis ...	Mucous membrane of lower lip.
	N. lingualis ...	N. sublingualis ...	Lingual gum of front teeth (Buente and Moral).
		Rr. linguales ...	Tongue to the foramen cæcum.
		Rr. isthmi fauc. ...	Part of tonsil.
	N. buccinatorius ...	... ...	Mucous membrane of cheek.
IV.—Pharynx and Larynx.			
II.—N. maxillaris	Ggl. sphenopal. ...	N. pharyngeus (Bock)	Region of mouth of Eustachian tube.
III.—N. mandibularis	N. lingualis ...	Rr. isthmi fauc. ...	Part of tonsil.
N. glossopharyngeus	... ...	Rr. pharyngei ...	Pharynx (with vagus).
	... ...	Rr. tonsillares ...	Tonsil and arch of palate.
	... ...	Rr. linguales ...	Base of tongue behind foramen cæcum.
N. vagus	... ...	Rr. pharyngei ...	Pharynx.
		R. internus ...	Base of tongue near epiglottis. Entrance to larynx and glottis.
	N. laryngeus sup....	R. externus ..	Mucous membrane of larynx below the glottis to the ventriculus Morgagni (Testut).

2.—THE TECHNIQUE FOR THE ANÆSTHETIZATION OF THE INDIVIDUAL BRANCHES OF THE TRIGEMINAL NERVE.

THE ANÆSTHETIZATION OF TRIGEMINUS I.

The first branch of the trigeminal nerve, the N. ophthalmicus, divides, as we have seen, into three branches, the Nn. frontalis, lachrymalis and naso-ciliaris.

For the anæsthetization of these individual branches according to the methods described by Braun and Peuckert, it is necessary to inject the anæsthetic into the orbit external to the muscular envelope of the bulb according to the course they run.

If the directions given be carefully followed injuries to the bulb may be easily avoided. Straight, long needles, as described above,

are used for the purpose; the employment of curved needles, as has been recommended by some authors, is unnecessary, and Braun even utters a warning against it. The injection of the individual branches of trigeminus I should be carried out at those points where, owing to the anatomical disposition of the bony cavity of the orbit, the needle can be introduced with the greatest ease and accuracy. The point of the needle should penetrate deeply into the orbit guided by the bone, and this is only possible where the bony orbital walls are flatter and not markedly hollowed out. Such spots are to be found at the lateral and the upper part of the medial wall of the orbit; at the lower wall a plane surface can also as a rule be found permitting of

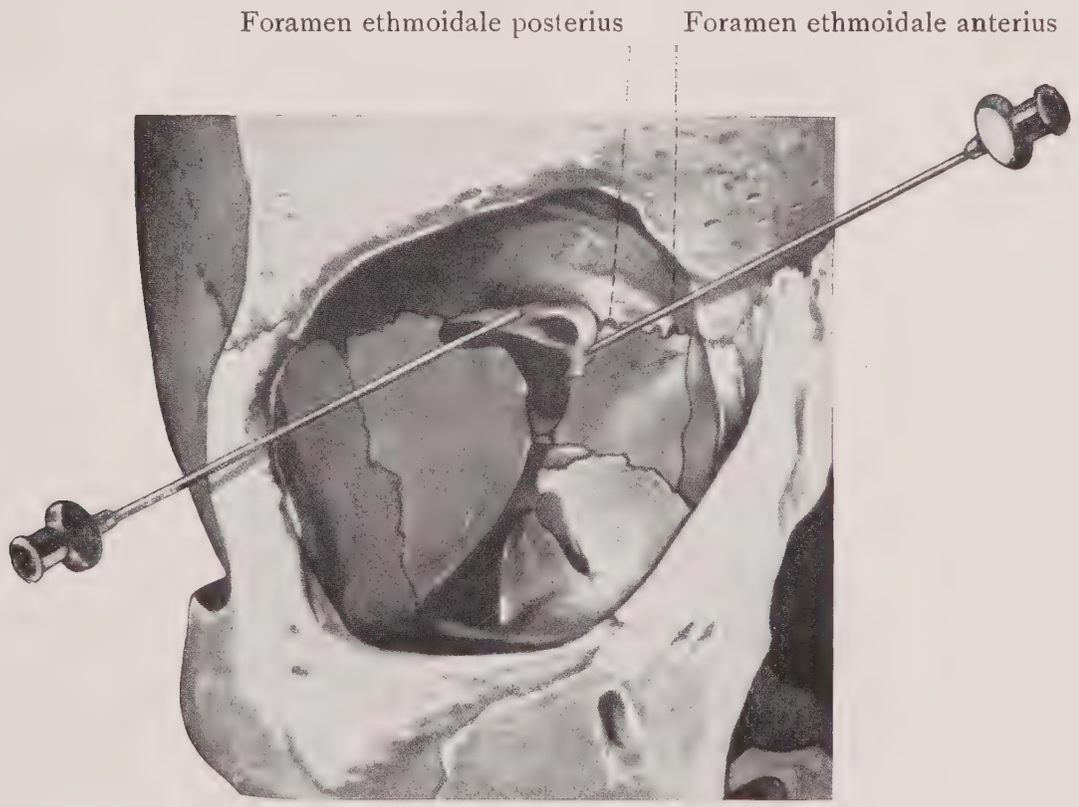

FIG. 12.—Medial and lateral orbital injections. (Braun.)

the needle being introduced here. Fig. 12 (taken from Braun) shows the introduced needles *in situ* for the medial and lateral orbital injections.

By the **medial injection** the branches of the N. naso-ciliaris and the Nn. ethmoidales are anæsthetized, by the lateral the N. frontalis and the N. lachrymalis.

As we shall have occasion to mention later, the foramen rotundum, the point of exit of the trigeminus II, the N. maxillaris, may be reached with the needle from the lower plane surface.

The points of puncture for these three orbital injections are shown in fig. 13.

The **lateral injection** for anæsthetizing the Nn. frontalis and lachrymalis is made at the point *a*, which is situated immediately above the lateral canthus.

According to Braun, the needle should be introduced at this point using the bone as a guide and keeping in touch with the latter, in the direction of the fissura orbitalis superior for 4·5 to 5 cm. At this spot one strikes on the upper wall of the orbit so that the further introduction of the needle is impeded. Braun injects 5 c.c. of a 1 per cent.

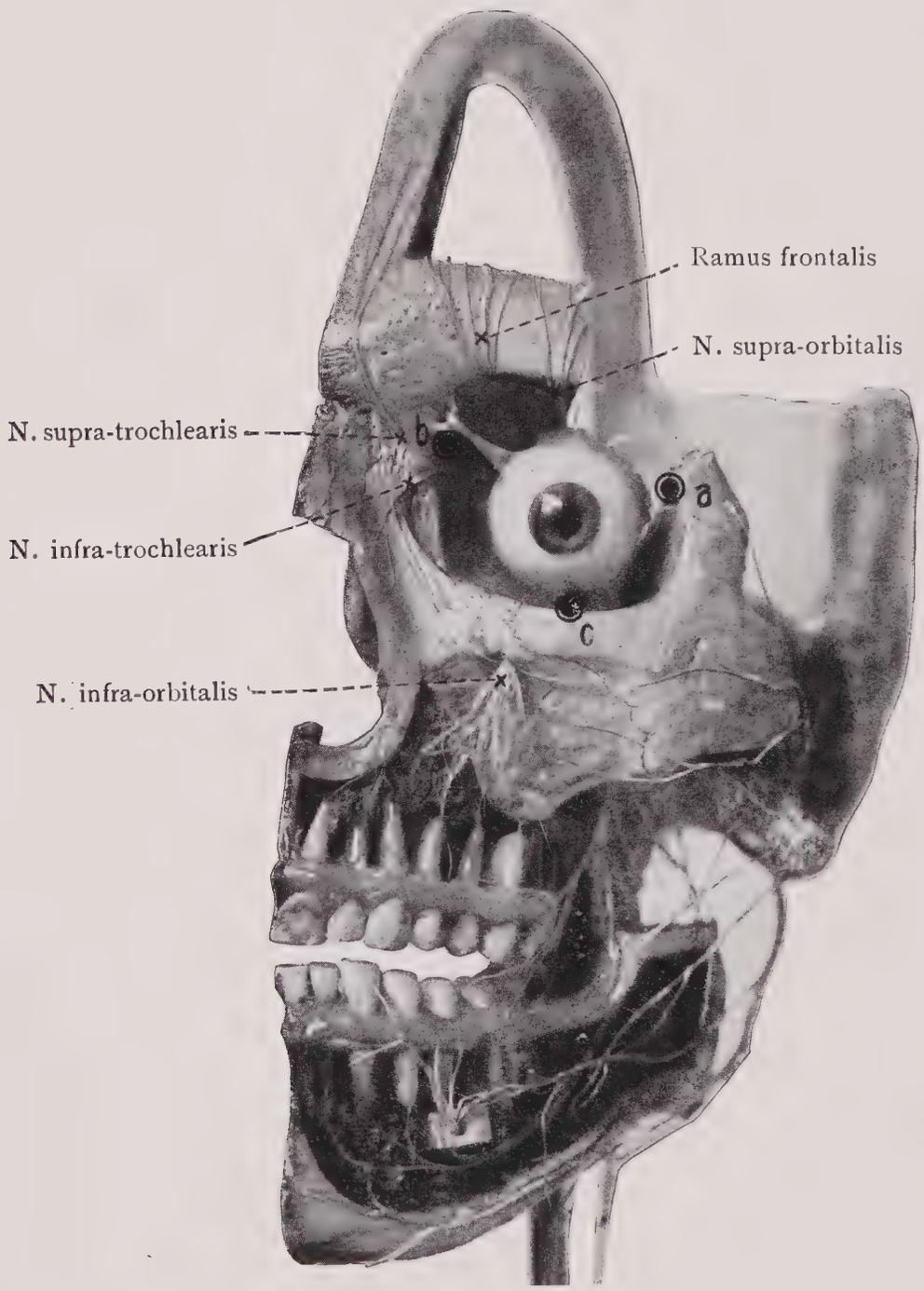

Fig. 13.—The orbital injections.

solution of novocain-suprarenin at this spot in the neighbourhood of the fissura orbitalis superior. Haertel advises that the needle should not be inserted to a greater depth than about 3 cm. and the injection made there.

By means of this lateral orbital injection we obtain anæsthesia

of the skin at the lateral canthus, at the medial canthus, over the upper lid, forehead and crown ; also of the conjunctiva of the lateral and medial part of the upper lid and a part of the conjunctiva of the lower lid.

The **medial orbital injection** for the anæsthetization of the Nn. ethmoidales is performed by inserting the needle at point *b*, which, according to Braun, is situated a finger's breath above the medial canthus (fig. 13).

The needle should be introduced horizontally under guidance of the bone to a depth of from 4 to 5 cm. Braun injects 5 c.c. of a 1 per cent. solution of novocain-suprarenin at this point, allowing it to be distributed along the medial wall of the orbit.

According to Haertel, the needle should be introduced for about 2 cm. when anæsthetizing the N. ethmoidalis anterior, which supplies the upper and anterior sections of the nasal mucous membrane and the skin at the point of the nose. This depth does not suffice, however, to reach the N. ethmoidalis post., which supplies the innervation of the posterior ethmoidal cells and the sphenoidal sinus. Since the deep introduction of the needle in the direction of the posterior ethmoidal foramen brings one into close proximity with the optic nerve, Haertel has suggested that in performing the medial orbital injection the needle should not be allowed to penetrate farther than 3 cm., and that one should trust to diffusion of the solution into the deeper parts.

According to Braun's experience, orbital injections are liable to produce slight protrusion of the bulb and œdema of the upper lid, both of which rapidly pass off. The patients did not complain of any discomfort. Since the orbital injection, according to Braun's method, is made along the bony wall external to the circulus tendineus and the muscular cone of the bulb, no influence ascribable to the injection is noticed on the optic nerve and the ciliary nerves.

Kredel reports a case in which amaurosis of the eye in question, lasting about ten minutes, was observed to follow an orbital injection. It is possible that this might have been produced by the suprarenin-anæmia, or by the anæsthetic itself.

Further, Jassenetzky reports transitory amaurosis, which appeared one day after the operation, and may be ascribed to inflammatory œdema of the orbit consequent on local anæsthesia induced for an operation for empyema of the frontal sinus.

For the purpose of anæsthetizing the bulb of the eye for enucleation or evisceration, it is necessary to perform retrobulbar anæsthetization of the Nn. ciliares longi and the ganglion ciliare.

Loewenstein introduces the needle from the centre on the lateral orbital margin for 4·5 cm. between the bulb and the conjunctiva ; he then turns the needle towards the medial line and thus reaches the

neighbourhood of the N. opticus and the ganglion ciliare. At this point he injects 1 c.c. of 1 per cent. solution of cocaine with suprarenin added. He also injects 0·5 c.c. of the same solution subconjunctivally round the bulb.

Siegrist circuminjects the retrobulbar tissues by means of a curved needle introduced from four points on the conjunctiva.

Mende recommends that a curved needle should be introduced from two points in the conjunctiva, one temporal and the other nasal, behind the bulb up to the neighbourhood of the point of entry of the optic nerve and ciliary nerves, and that 2 c.c. each of 1 and 2 per cent. novocain solution with suprarenin added should be injected. Further, 1 c.c. of the same solution is injected subconjunctivally into the neighbourhood of the attachment of the recti muscles.

Seidel injects 1 to 2 c.c. of 1 per cent. novocain-suprarenin solution subconjunctivally round the bulb. He then injects 1 c.c. of the solution behind the bulb by means of a straight needle introduced from four points through the conjunctiva, likewise 1 c.c. each as the needle penetrates into the retrobulbar tissues.

THE ANÆSTHETIZATION OF THE TRIGEMINUS II.

The second branch of the trigeminal nerve, the N. maxillaris, may be reached by the needle in several ways at its point of emergence from the base of the skull at the foramen rotundum.

As we have seen, this nerve runs a fairly horizontal course from the foramen rotundum to the pterygo-palatine fossa, which it transverses in the direction of the infra-orbital canal. Passing through this canal it emerges at the N. infra-orbitalis in the foramen of the same name.

The second branch of the trigeminal may be reached at the foramen rotundum either via the orbit, or, as was first attempted, by introducing the needle under the zygomatic arch and pushing it onwards along the posterior surface of the upper jaw into the pterygo-palatine fossa.

The orbital method was, according to Haertel, first suggested by Payer, but the former was the first to actually carry it out and develop it into a method. Haertel calls this method the **axial puncture of the foramen rotundum.**

If a needle be guided in a skull starting from the lateral part of the lower margin of the orbit in the sagittal direction, it will reach the infra-orbital canal between the sphenoid and the maxillary bones, after passing through the inferior fissure (spheno-maxillary). At the end of the infra-orbital canal lies the foramen rotundum. Before reaching this point, however, the needle will be found to be impeded by the pterygoid surface of the sphenoid. If the needle be now directed

upwards and medially along this resisting surface it will reach the foramen rotundum. The distance between the foramen rotundum and the lower orbital margin is about 4·5 cm.

As the foramen is very narrow and completely filled by the N. maxillaris, the needle will meet with considerable resistance and the injection will have to be made with a certain amount of pressure. If the nerve be correctly struck at the foramen, the patient will feel pain radiating over the area supplied by the trigeminus II.

The **technique** of the **orbital injection** into the **foramen rotundum, according to Haertel's method,** is as follows :—

The needle is introduced at the middle of the lower orbital margin between the zygomatico-maxillary suture and the lateral inferior angle of the orbit (fig. 13, point *c*). With the index finger of the left hand the bulb is pressed upwards and the needle pushed horizontally and sagittally into the deeper tissues between the finger and the lower orbital wall, until having traversed the inferior orbital fissure (sphenomaxillary) it strikes upon the pterygoid surface of the sphenoid at a depth of 4 to 5 cm. Having met with this bony resistance one carefully feels along the surface in an upward and inward direction with the point of the needle until the patient complains of radiating pains in the area of distribution of the maxillary nerve. Having reached the foramen the needle is pushed onward for a few more millimetres into it, and 0·5 c.c. of a 2 per cent. solution of novocain-suprarenin is injected under fair pressure. If the injection has been successfully carried out anæsthesia of the entire area supplied by the second branch of the trigeminal nerve will supervene. The direction followed by the needle is indicated in fig. 14 by an arrow.

If the technique be correctly carried out injury to the optic bulb and nerve can be avoided, but, according to Haertel, hæmatomata may possibly occur. Further, Haertel states that the orbital route is only possible in 90 per cent. of skulls.

The **anæsthetization of the maxillary nerve in the pterygo-palatine fossa** from a point situated below the zygomatic arch was first attempted by Matas in 1900. Schloesser employed this route for alcohol injections in neuralgic cases, and Braun further extended the method to one for inducing local anæsthesia.

According to Haertel, the point of the needle reaches the foramen rotundum in only 33 per cent. of these cases by this route. As a rule the anæsthesia induced is to be explained by the fact that the anæsthetic reaches the nerve by diffusion through the loose tissues of the pterygo-palatine fossa.

The **technique** for injecting the second branch of the trigeminal nerve from the lower border of the zygomatic arch is as follows, according to Braun :—

The needle is inserted immediately posterior to the lower palpable

angle of the malar bone and pushed onwards in an inward and upward direction. It glides along the maxillary tuberosity (tuber-maxillare), and if this be very much arched, the point of insertion should be placed more posteriorly. Sometimes the point of the needle catches on the great wing of the sphenoid, and its direction must then be carefully altered. Having reached a depth of 5 to 6 cm. the nerve is struck in the fossa.

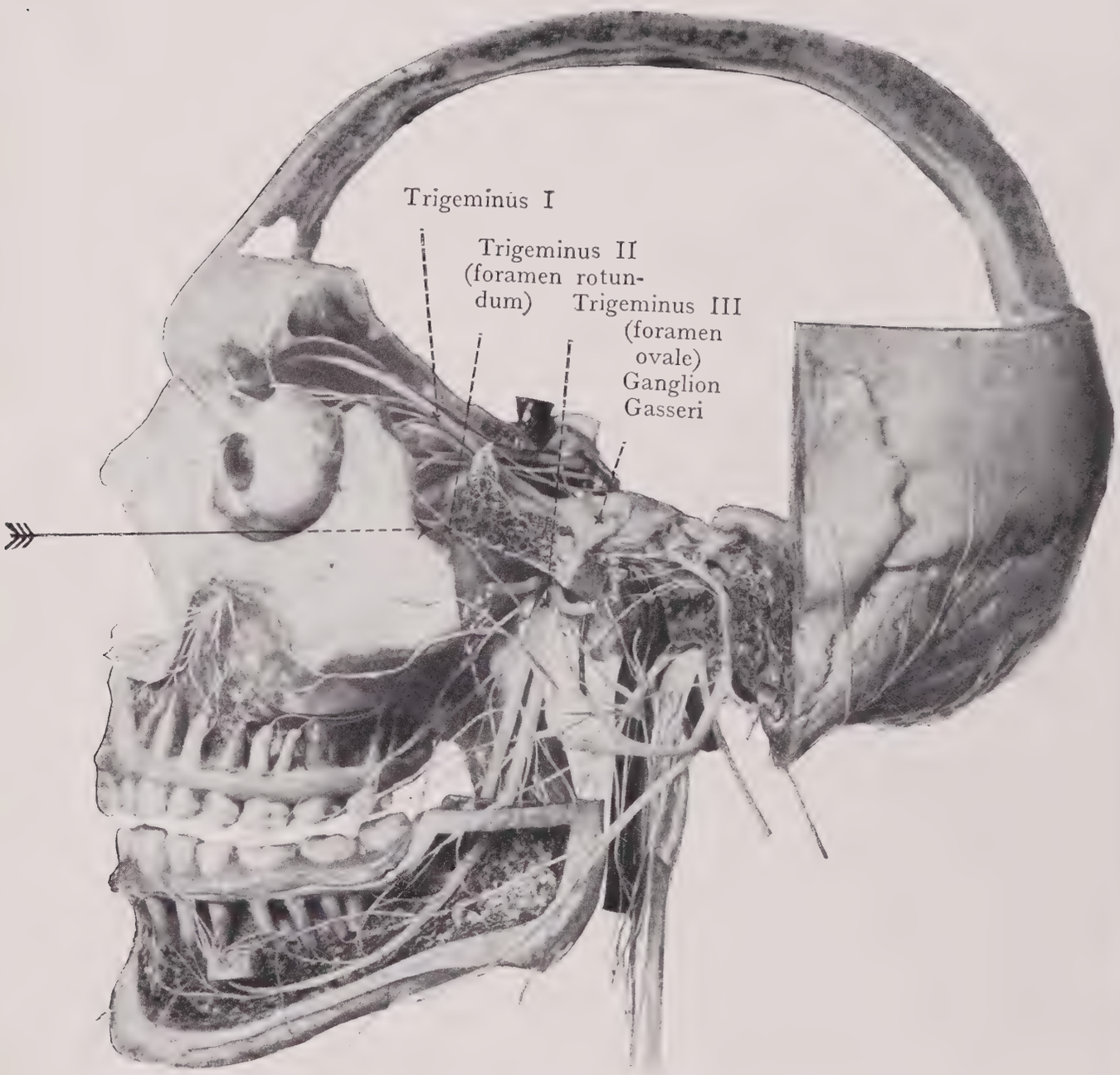

FIG. 14.—Orbital injection into the foramen rotundum from above the zygoma.

Braun now injects 5 c.c. of 1 per cent. novocain-suprarenin solution, moving the needle gently and slightly to and fro. As he withdraws the needle he injects further 5 c.c. of the same solution behind the upper jaw to cause contraction of the branches of the maxillary artery. If the maxillary nerve has been correctly struck the patient feels radiating pains in the face.

If the pushing of the needle past the maxillary tuberosity presents any difficulty, it may be necessary to re-insert the needle at a point nearer the centre of the zygomatic arch, and to inject double the above dose, that is about 10 c.c. of 1 per cent. novocain-suprarenin solution, so that the anæsthetic may reach the nerve by diffusion.

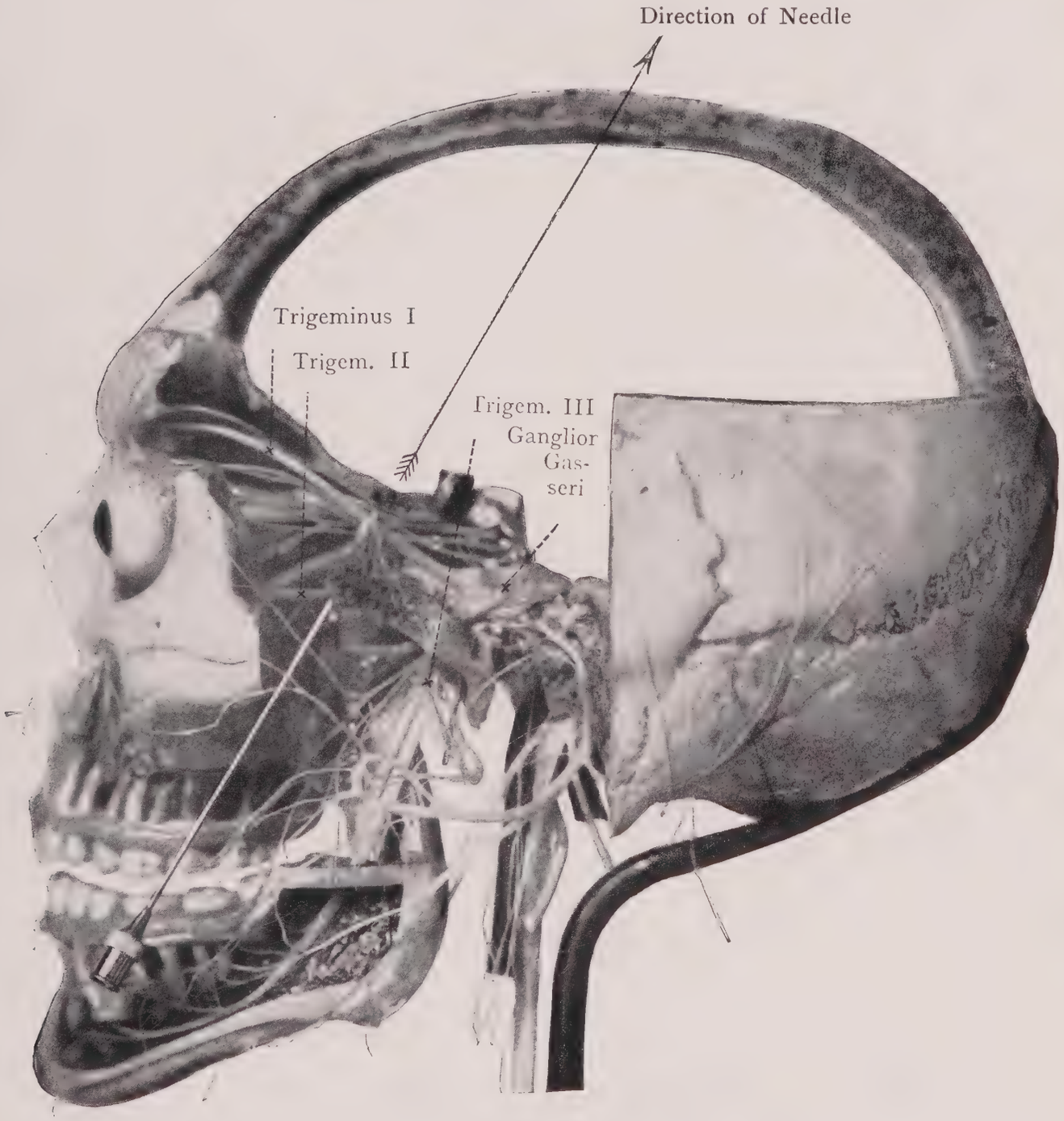

FIG. 15.—Injection into the foramen rotundum from below the zygoma. (The arrow indicates the direction of the needle.)

In fig. 15 the needle will be seen inserted into the foramen rotundum; the arrow indicates the direction of the needle. Before carrying out the technique it is well in this case, as indeed in the case of all anæsthesias of the trigeminal nerve, to practise on the skull and

note the exact direction taken by the needle, the skull being placed before one whilst operating.

The direction is easily fixed in the case of the second branch of the trigeminal by an imaginary line drawn from the first or second bicuspid of the lower jaw crossing the skull in an inclined plane towards the centre of the roof of the skull. Adherence to this guiding line has rendered good service to the author (fig. 15).

The technique of the method just described for reaching the foramen rotundum with the needle is comparatively simple and certain in its results, and it can therefore be thoroughly recommended.

Another method, that of Ostwalt, might be mentioned. He inserts the needle from the mouth immediately behind the last molar and pushes the needle along the infra-temporal surface (planum infra-temporale) until he reaches the pterygoid fossa.

A **fourth method** is that described **by Offerhaus.** By means of dividers he measures the distance between the centres of the two zygomatic arches, and after deducting from this the distance between the superior alveolar processes behind the molars, he deduces the distance of the foramen rotundum from his point of puncture. The latter is situated either above or below the middle of the malar bone. The method cannot be recommended on account of its being complicated; it also offers no greater certainty of finding the foramen rotundum than the method of Braun-Matas does.

ANÆSTHETIZATION OF THE TRIGEMINUS III.

The third branch of the trigeminal nerve, the area of sensory distribution of which we have described above, emerges at the base of the skull by the foramen ovale. Ostwalt, in administering alcohol injections, introduced a needle bent at an angle through the open mouth behind the third upper molar piercing the external pterygoid muscle and thus reached the foramen ovale.

Schloesser employs another method for the same purpose. He introduces the needle at the anterior border of the masseter, pierces the cheek and enters the buccal cavity, where he feels for the point of the needle with his finger introduced into the mouth and pushes it onwards towards the great wing of the sphenoid. The point of the needle is then supposed to be situated in front of the foramen ovale. The method is unsatisfactory, in that the needle has to traverse the cheek.

Harris, Alexander, Offerhaus and Braun have suggested the **transverse route for reaching the foramen ovale.**

According to Braun the point of introduction is situated below the middle of the malar bone, the needle is then pushed in a transverse direction towards the skull. Here again it is well to have a skull at

hand in which the exact direction is indicated by another needle placed in the proper position. The needle is pushed onwards till it meets the pterygoid process, the point is now about 1 cm. distant from the foramen ovale. The depth to which the needle has penetrated is noted and the latter is retracted up to the subcutaneous cellular tissue and then inclined backwards at a slight angle and again pushed into the deep tissues to the same distance. The point now lies directly in front of the foramen ovale. At this moment the patient should feel pain radiating towards the lower jaw. It is at this spot that Braun injects 5 c.c. of 1 per cent. novocain-suprarenin solution.

This tranverse route employed by Braun to reach the foramen ovale is easily followed and very accurate, but, as Haertel has pointed out, it may be rendered impracticable owing to anatomical variations in the base of the skull.

We can strongly recommend the **anterior method** devised by Haertel for injecting the Gasserian ganglion, by which the foramen ovale may be reached from the front. This method has also been employed for some time with success by the author. It differs from Schloesser's method in that the piercing of the buccal mucous membrane by the needle is avoided. The needle is introduced below the malar bone at a point on the cheek at the level of the upper molars and pushed on between the ramus of the lower jaw and the maxillary tuberosity to the infra-temporal surface.

The method, as practised by Haertel, which may be employed for anæsthetizing both the third branch of the trigeminal nerve and the Gasserian ganglion is as follows :—

A broad wheal is made on the cheek at the level of the alveolar border of the second upper molar under the zygomatic arch, so as to permit of the point of introduction of the needle being varied a little if desired. At this point the long fine needle, one about 10 cm. long will suffice, is inserted into the skin. The index finger of the left hand is now introduced into the buccal cavity, whilst the right hand holds the syringe. By pushing the needle onwards the point passes the border of the lower jaw and the maxillary tuberosity. The needle is now guided by the finger in the mouth round the buccinator muscle in a curved direction, and any injury to the mucous membrane is thus avoided. When the needle has reached the infra-temporal fossa the external pterygoid muscle is traversed and the infra-temporal surface reached. The depth attained should amount to about 5 to 6 cm.

This point can be easily marked on the needle. It is well to measure the length of the needle used and test the distance on the skull before the operation. By this means it is also possible to determine the direction of the axis of the needle, a knowledge of

which is essential if the foramen ovale is to be reached with any certainty.

Haertel has provided a small sliding attachment to his needles which can be fixed at any point. Such a needle undoubtedly facilitates the whole procedure, but it is not absolutely necessary.

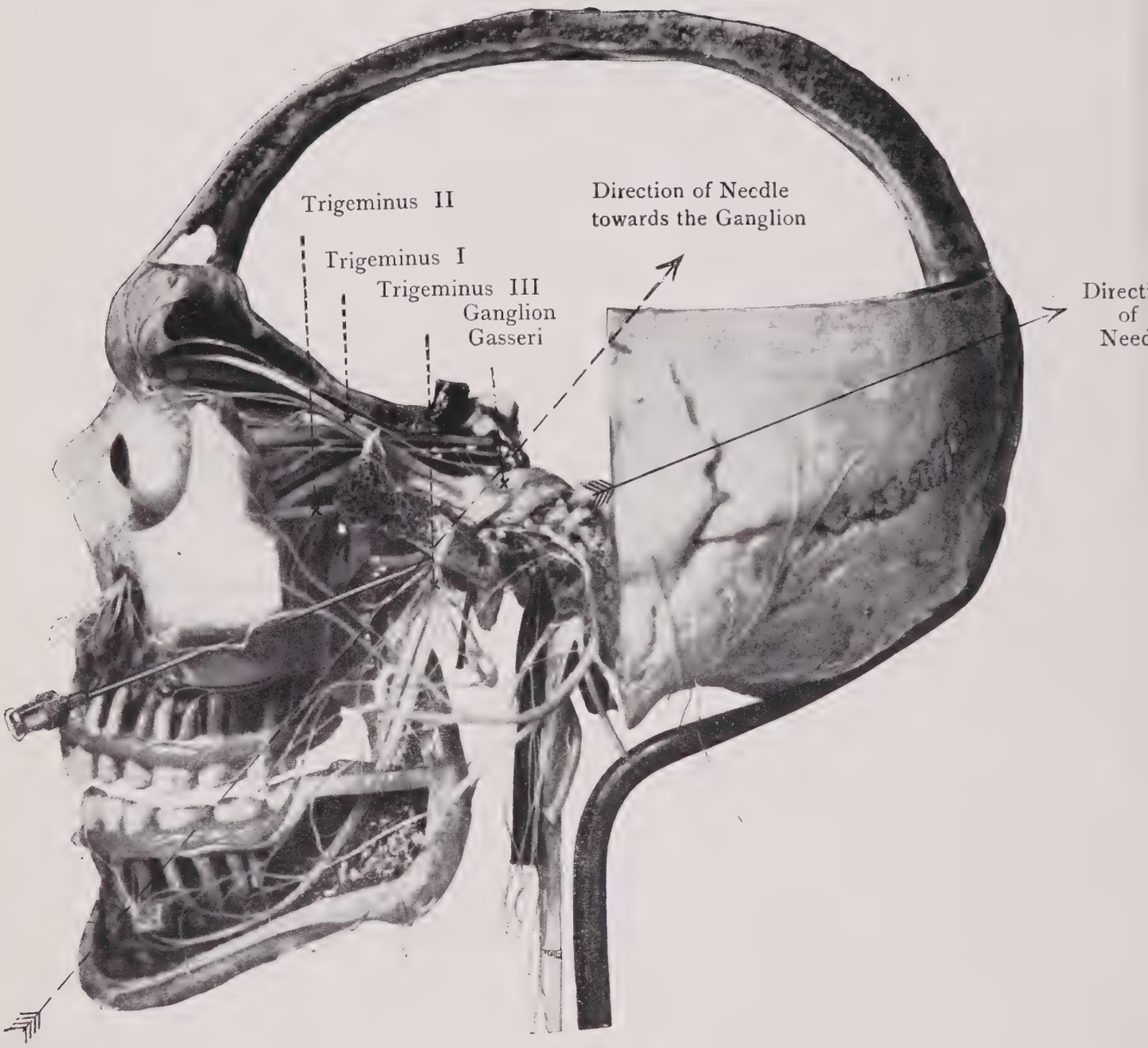

FIG. 16.—Injection into the foramen ovale. (The dotted arrow shows the depression of the needle to reach the Gasserian ganglion.)

It is most important to note not only the depth but also the direction of the needle.

According to Haertel, when viewed from in front the imaginary axis of the needle if produced would pass through the pupil of the eye of the same side. When seen from the side the needle points to the articular tubercle of the zygomatic arch, that is to say the prolonged

imaginary axis would pass through this point. It is very advisable to keep to these two guiding points. If the direction of the needle be inclined too far forward the pterygo-palatine fossa will be reached, if too far back the carotid foramen or the jugular foramen may be struck.

In the infra-temporal fossa the internal maxillary artery is crossed ; the danger of injuring it and the consequence of such an accident are not very serious. If thin needles be used and dexterity employed in introducing them in a straight line the artery will not be encountered. Haertel and the author have so far met with no instance of hæmatoma occurring.

Before Haertel pushes the point of the needle into the foramen ovale from the infra-temporal fossa, he places his movable index 1·5 cm. from the surface of the skin so as to keep himself informed as to how much deeper he is penetrating.

If one merely wishes to anæsthetize the third branch of the trigeminal nerve in the foramen ovale, without penetrating further along the bony canal to the Gasserian ganglion, the needle need not be introduced at so steep an angle, but is pushed onwards more horizontally below the zygomatic arch in the direction of the external occipital protuberance.

In fig. 16 the needle is shown as introduced from below the zygomatic arch into the foramen ovale. The axis of the needle, which is represented by the arrow, points towards the external occipital protuberance. This direction is easily noted on a skull that is held before the operator and thus kept in view. The external puncture on the cheek is situated about 2·5 cm. external to the angle of the mouth.

The author has always been able to reach the third branch of the trigeminal nerve at the foramen ovale successfully by this method. When viewed from in front the direction of the needle is the same as that given by Haertel. The point of the needle lies on an axis which if produced would pass through the pupil of the eye of the same side (fig. 17).

In the method used for reaching the Gasserian ganglion through the foramen ovale, as described according to Haertel above, the direction of the axis of the needle when viewed from the side is different. The needle is introduced more steeply, as may be seen in fig. 16, where it is represented by the arrow which passes through the foramen ovale. The direction is more inclined towards the vertex of the skull, whilst if produced downwards it would pass nearer the mental foramen of the lower jaw. The difference in direction here referred to depends on the shape of the bony canal through which the third branch of the trigeminal nerve passes, and which is inclined steeply, as may be seen from fig. 16.

Anæsthesia may be induced in the third branch of the trigeminal nerve in the foramen ovale with 5 c.c. of the 1 to 2 per cent. solution. If the nerve has been correctly struck by the needle pain radiating to the tongue and lower jaw is noticed by the patient.

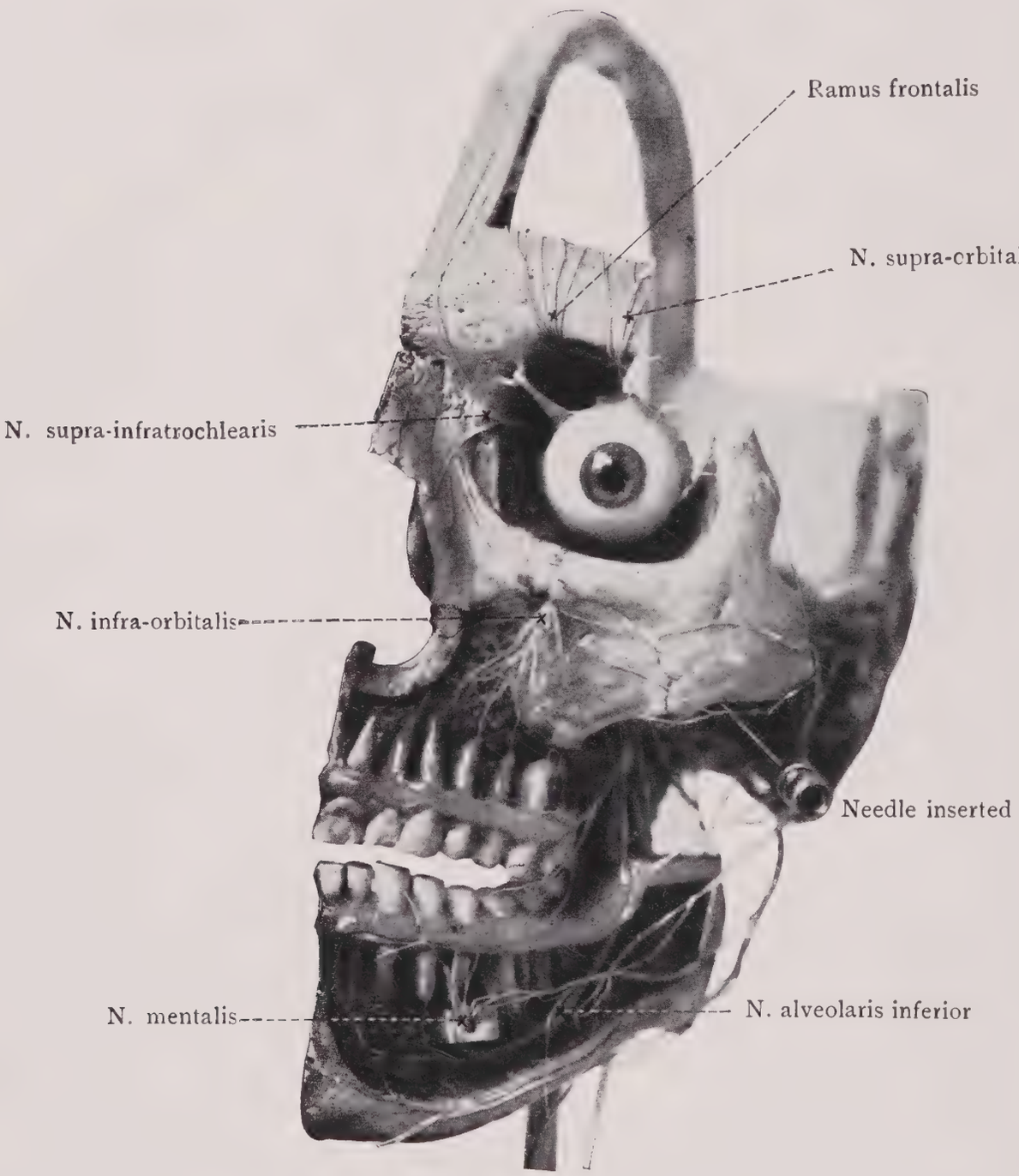

FIG. 17.—Direction of needle when injecting into the foramen ovale viewed from the front (towards the pupil).

If the Gasserian ganglion is to be anæsthetized, Haertel's method above described is the best.

Haertel summarizes the various stages of the procedure briefly as follows :—

(*a*) Introduction of the needle into the cheek at the level of the alveolar border of the second upper molar tooth, and production of

a wide wheal which permits of varying the direction of the point of insertion of the needle either anteriorly or posteriorly.

(*b*) Before introducing the needle, which should be about 10 cm. long and have a flat-ground point, the probable depth of the infra-temporal surface (about 5 to 6 cm.) is marked on the needle by means of an aseptic scale and the sliding attachment.

(*c*) Introduction of the needle guided by the finger between the anterior border of the ascending ramus of the lower jaw, and the maxillary tuberosity round the buccinator muscle to the infra-temporal fossa.

(*d*) Note the direction : the needle viewed from in front, should point exactly to the pupil of the eye of the same side, viewed from the side, to the articular tubercle of the malar.

(*e*) Striking the foramen ovale, guided continually by the hard even surface of the infra-temporal surface and entering the foramen from the anterior external longitudinal border.

(*f*) Having reached the foramen (cessation of the feeling of resistance, radiating pains to area of distribution of third branch), the sliding attachment is drawn back 1·5 cm. from the skin and the needle introduced into the foramen ovale until pains are felt in the area of distribution of the second branch also.

(*g*) Attachment of the syringe and slow injection of 2 per cent. novocain-suprarenin solution, not exceeding 1 c.c.

(*h*) Immediate testing of the anæsthesia.

These are the points emphasized by Haertel in the anæsthetizing of the Gasserian ganglion.

The instruments used by Haertel consist of a 10 cm. long and 0·8 mm. thick nickel-plated needle having the point flattened, and provided with a movable sliding index which can be placed in position marking various distances which are measured by a metal scale. The whole instrumentarium may be obtained from Windler, Berlin.

These instruments are not all absolutely necessary to attain the object aimed at, as has already been mentioned. The same results may be obtained with a 10 cm. long needle on which the distance to which the needle may be introduced has been marked.

Haertel places the patient on the operating table with the upper part of the body slightly raised, the head being supported by a bolster, when he anæsthetizes the Gasserian ganglion.

The skin is disinfected with alcohol and tincture of iodine, the wheal on the cheek being then produced.

Difficulties may arise on account of anatomical variations of the foramen ovale in question. According to Haertel's experience the procedure may be easy on one side and difficult on the other in the same patient, as the foramina usually vary on the two sides. Once the foramen has been reached, which is recognized by the

radiating pains already mentioned, the needle is introduced for a further 1·5 cm. The injection should be made very slowly drop by drop.

If the injection has been successful anæsthesia usually supervenes immediately. Haertel has known it to be delayed up to five minutes after the injection.

The technique of such ganglion anæsthesias is not easy, and requires some practice in local anæsthetic procedures. It cannot be recommended to those who lack dexterity and practice, although Haertel maintains that when properly carried out, and if the instructions be carefully followed, all untoward concomitant symptoms can be avoided.

(b) Local Anæsthesia in Operations on Individual Regions of the Face.

The methods above described having reached so high a state of perfection that conduction-anæsthesia can be induced in the individual branches of the trigeminal nerve or in the Gasserian ganglion, and thus by simple means and with small quantities of the anæsthetic agent large areas of the face may be rendered insensitive to pain, it is natural that one should desire to employ these conduction-anæthesias as much as possible.

As we shall see, this is possible in most cases, but it will not always be possible to dispense with infiltration-anæsthesia induced in the face areas surrounding the field of operation, for the small terminal twigs of the neighbouring nerves and of the other side interdigitate with those of the trigeminal nerve.

We therefore combine conduction-anæsthesia with infiltration-anæsthesia, that is with the subcutaneous injection about the field of the operation.

In this case also the past-master of local anæsthesia, Braun, has pointed out the way we should go, and described methods according to which typical and atypical operations on the face and jaws can be performed under perfect anæsthetic conditions.

OPERATIONS ON THE EYE AND FRONTAL SINUS.

The operation connected with the eye that mainly concerns the general surgeon is that of **evisceration of the eyeball.** The method of inducing the necessary local anæsthesia for this purpose has been already described above (pp. 33 and 34). For **operations on the eyelids** whether the upper or lower, conduction-anæsthesia is

unnecessary, simple infiltration-anæsthesia being fully adequate, and being possible from one point of puncture subcutaneously.

In fig. 18 the points at the upper and lower orbital margin are shown, from which a small quantity of 1 per cent. novocain-suprarenin solution may be injected towards the inner and outer canthus in the directions indicated by the arrows. The entire eyelid, including its conjunctiva, is rendered insensitive, so that operations, plastic or of some other kind, can be readily undertaken.

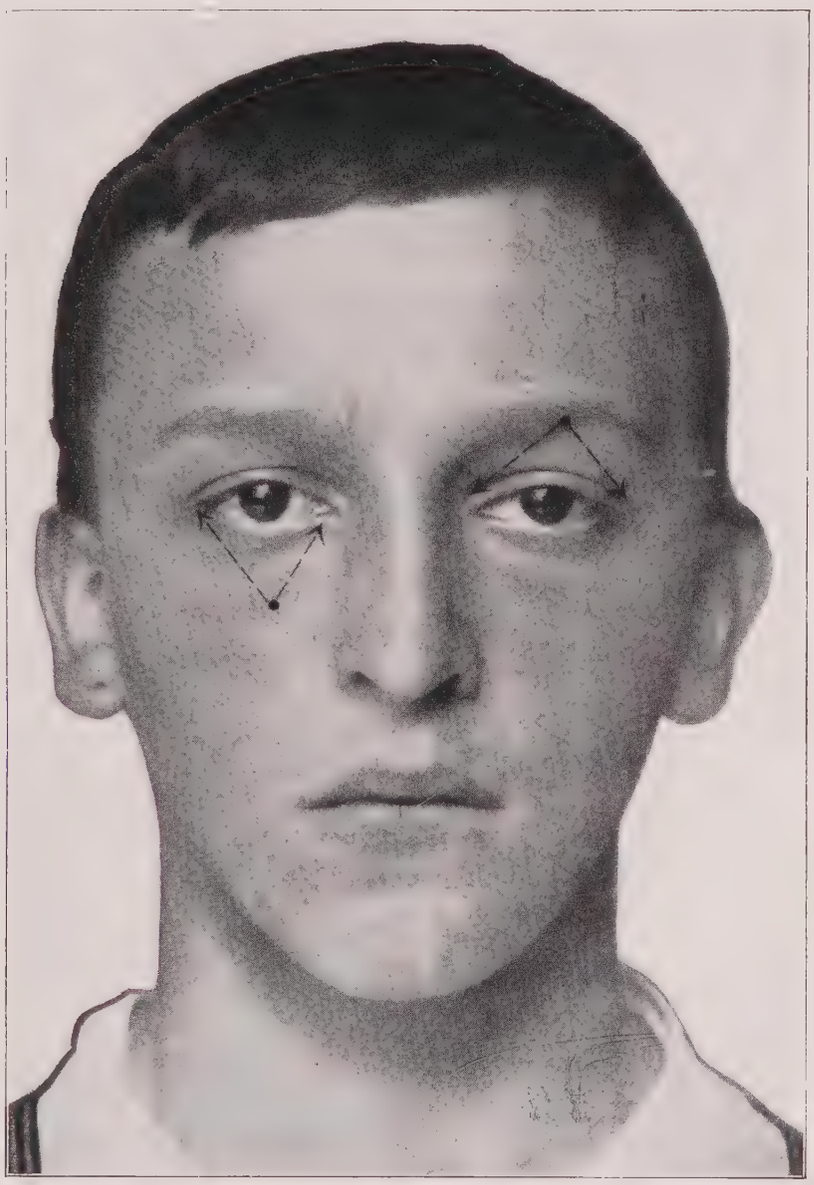

FIG. 18.—Anæsthetizing the eyelids.

In a similar manner warts or smaller tumours, rodent ulcers, &c., can be removed from the face under simple infiltration-anæsthesia without interrupting the conduction of the trigeminal branches.

Not even a so-called Hackenbruch rhombus is required; that is to say, injection proceeding from four points from which the area surrounding the field of operation is injected; it is usually sufficient to start with one wheal, and from this inject the anæsthetic (0·5 per

cent. solution of novocain-suprarenin) underneath and around the small tumour.

It is a different matter when we have to deal with **deep operations** in which the bones may have to be dealt with at the same time. In these cases, as already hinted, a combination of conduction-anæsthesia by interrupting one or other of the branches of the trigeminal

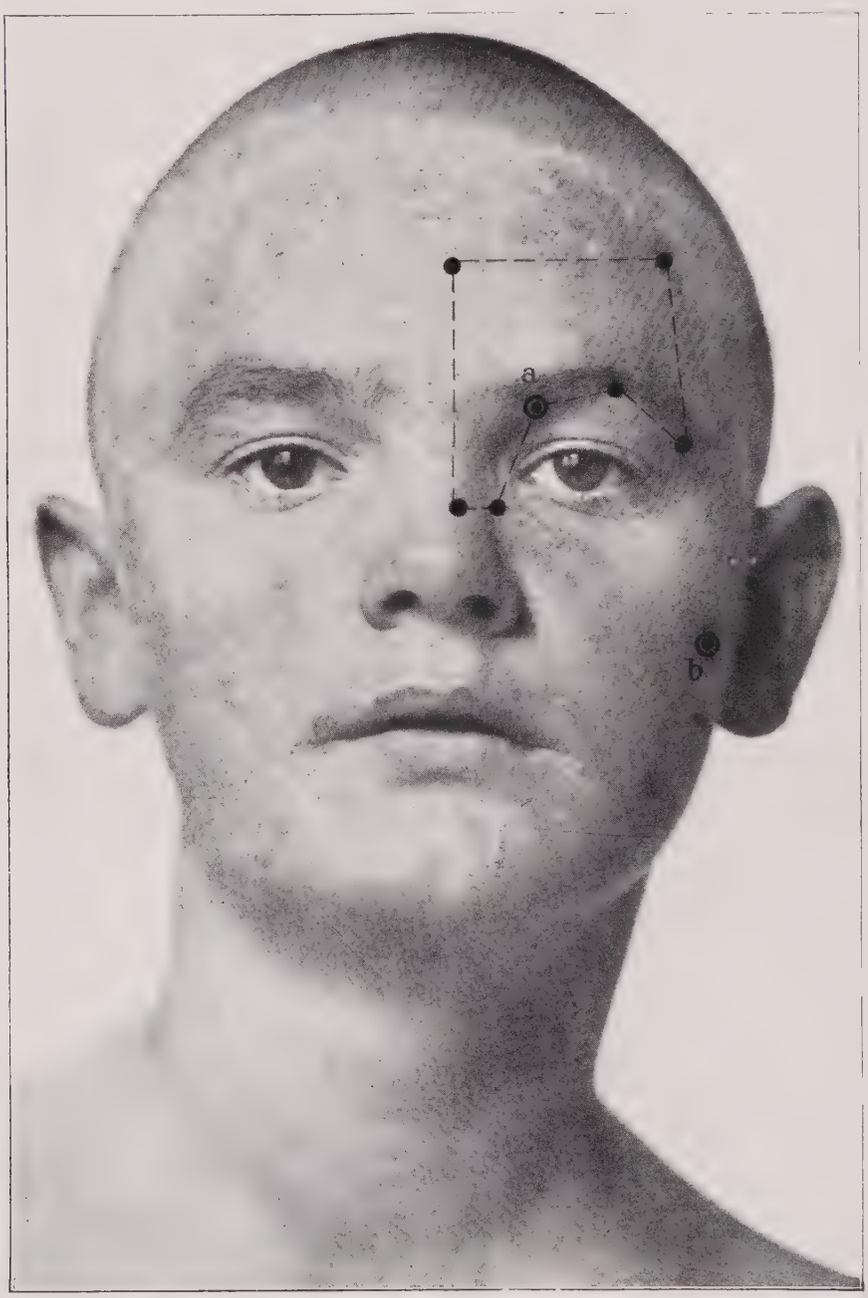

FIG. 19.—Anæsthetizing for frontal sinus operations.

nerve with infiltrating injections round the field of operation will become necessary. For the conduction-anæsthesia 5 c.c. of 1 to 2 per cent. solution of novocain-suprarenin will suffice, whilst for the infiltration-anæsthesia it will be better to use 0·5 per cent. solutions of the same combination.

Braun has described several typical face operations which may be carried out in this manner under local anæsthesia.

For unilateral or bilateral radical **operations on the frontal sinus** for empyema of those cavities anæsthesia should be induced as follows (Braun, *cf.* fig. 19) :—

From the point *a** a medial orbital injection is made to interrupt the conduction of the N. ethmoidalis anterior, which supplies the mucous membrane of the frontal sinus. (This procedure has been already described in detail on p. 33.) As in performing Killian's

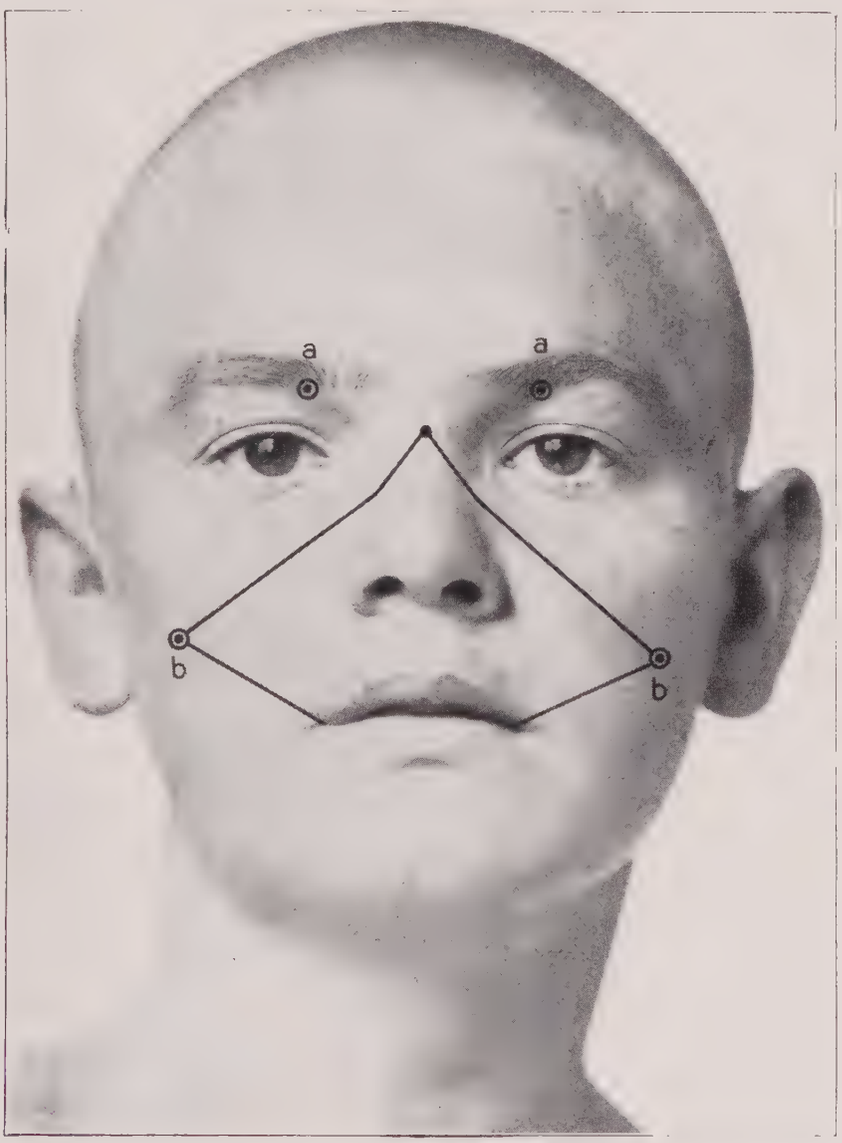

FIG. 20.—Anæsthetizing for operations on the nose.

operation the nasal mucous membrane is also involved, the second branch of the trigeminal, the maxillary nerve, must also be anæsthetized. This is done from point *b*. Then the surface of the field of operation is circum-injected as shown in fig. 19. By this means the supra-trochlear and supra-orbital nerves are interrupted.

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* The points shown in the figures which are surrounded with rings indicate deep injection ; in the case of the face the production of conduction-anæsthesia of the trigeminus.

OPERATIONS ON THE NOSE.

Anæsthesia of the entire nose, that is to say, of both the soft parts, and the bones as well as the nasal cavity and its adnexa, is achieved by bilateral medial injection, by bilateral interruption of the maxillary nerve and circum-injection of the field of operation, as shown in fig. 20.

The medial orbital injection is carried out from the point *a* (N. ethmoidalis ant.), the trigeminus II is interrupted from the point *b*.

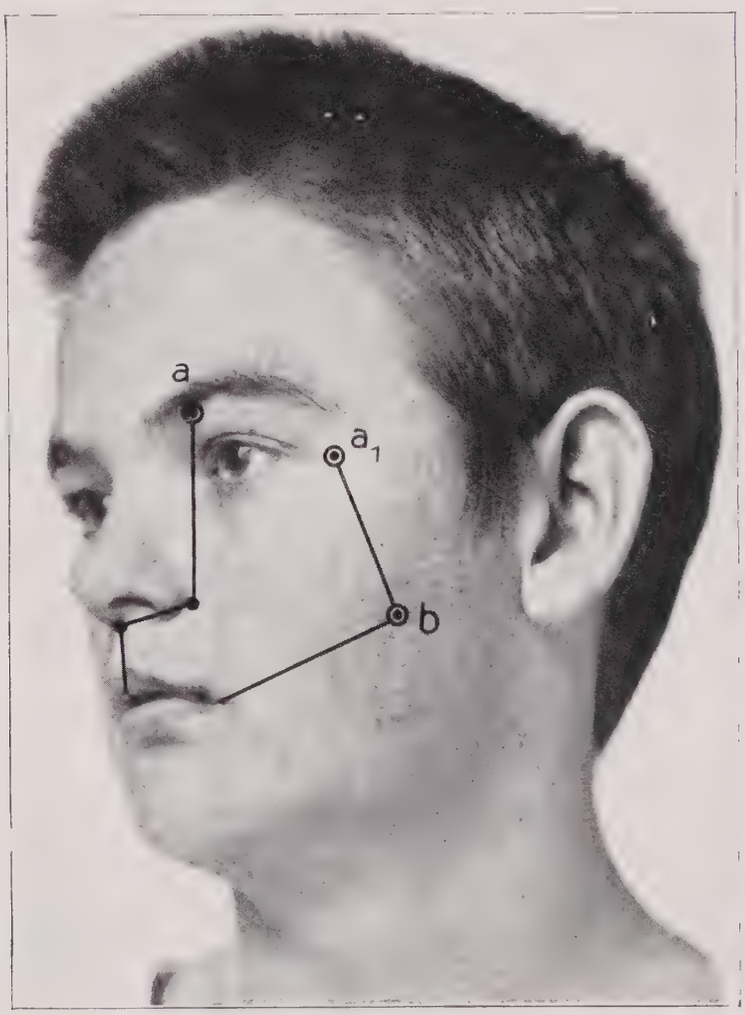

FIG. 21.—Anæsthetizing for operations on the upper jaw.

Further it is necessary to circum-inject the field as shown in the figure. Braun recommends this method of procedure in extirpation of the nose, turning it back as a flap to gain access to the antra and also for operations on the hypophysis.

OPERATIONS ON THE UPPER JAW.

For **resection of the upper jaw** the following procedure of anæsthetization is necessary (Braun) (fig. 21). First the two orbital injections are carried out at points *a* and a^1; the lateral injection from point a^1 may be dispensed with if the floor of the orbit is

not to be removed. At point *b* the trigeminus II is interrupted. Then the field of operation is circum-injected as shown in the figure. Finally, the palate is infiltrated along the line of incision.

It is particularly in this operation that the great advantage of local anæsthesia becomes so very evident. As the cases usually consist of old or middle-aged people who would be endangered to a certain extent by general anæsthesia, this risk is avoided, as is also that due to aspiration and the severe hæmorrhage, the latter being diminished owing to the suprarenin-anæmia induced. Further, the fact that in face operations it is far more convenient to work under local anæsthesia, since the disturbance due to the application of the mask is avoided, is an advantage by no means to be underestimated.

Ligature of the external carotid previous to the main operation in order to prevent excessive loss of blood is not necessary on account of the suprarenin-anæmia induced, but if it should be required it can also be performed under local anæsthesia.

OPERATIONS ON THE LIPS.

In operating on the upper and lower lips conduction-anæsthesia is unnecessary. For these operations (extirpations of tumours, carcinomatous or otherwise, plastic operations, &c.) simple infiltration-anæsthesia from one point from which the field of operation is circum-injected in both directions divergingly, will suffice (fig. 22). It is immaterial whether it is a case of merely removing a wedge or of extensive removal of pieces of tissue from the lips, to be followed by a plastic operation with portions of tissue from the cheek or chin (*cf.* also figs. 23, 40 and 41).

Since in the case of the lip we are dealing with thick layers of tissue, the needle must be introduced both subcutaneously and under the mucous membrane, infiltrating from one point to the other, so that the tissues of the lip or cheek are infiltrated throughout their entire thickness. For such infiltration solutions of 0·5 per cent. novocain-suprarenin suffice, and large quantities may be used, up to 100 c.c. or more; for instance in plastic flap operations after excision of the lip.

Fig. 23 represents the circum-injection of the field in a plastic flap operation of this type, the flaps being taken from the cheek. If owing to the extension of the tumour the periosteum or the bones of the lower jaw be involved it will be necessary to include this in the field of operation; in such a case the conduction of both lingual and inferior alveolar nerves may be interrupted either on one or both sides at the lingula of the lower jaw.

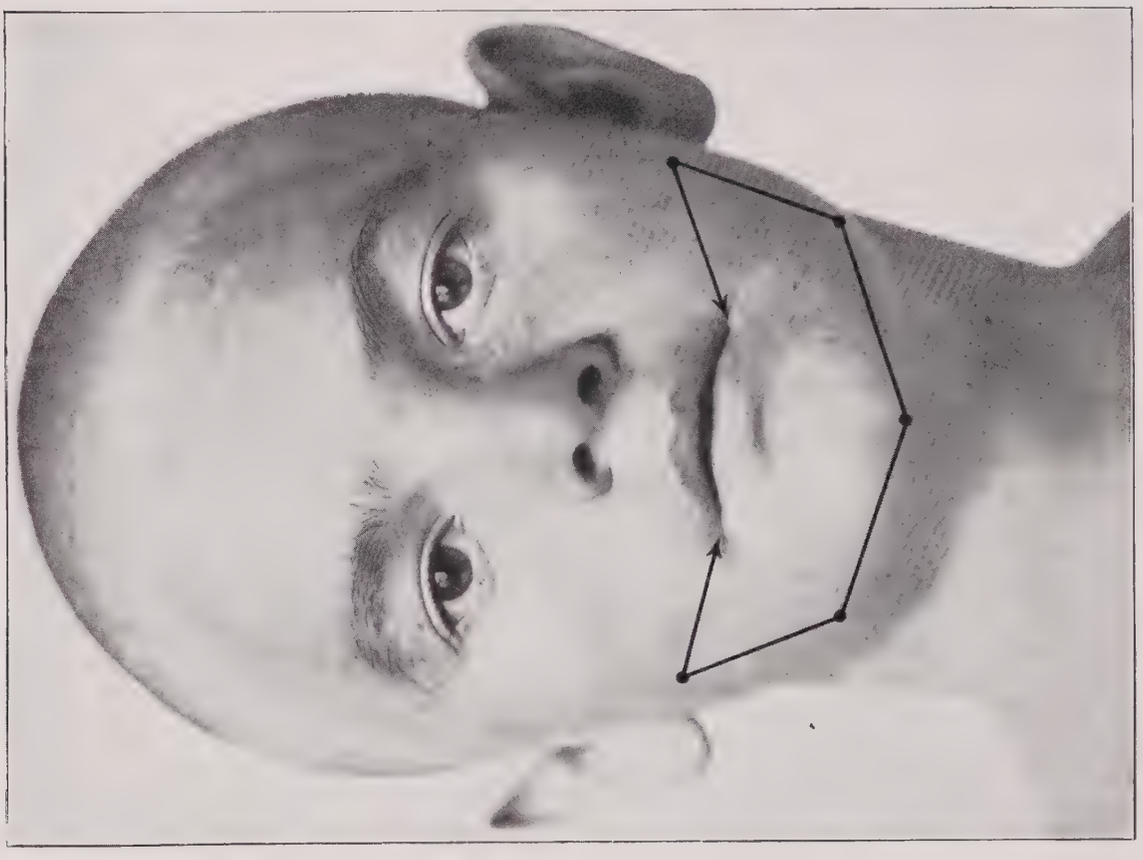

FIG. 23.—Anæsthetizing for operation on lower lip with plastic flaps.

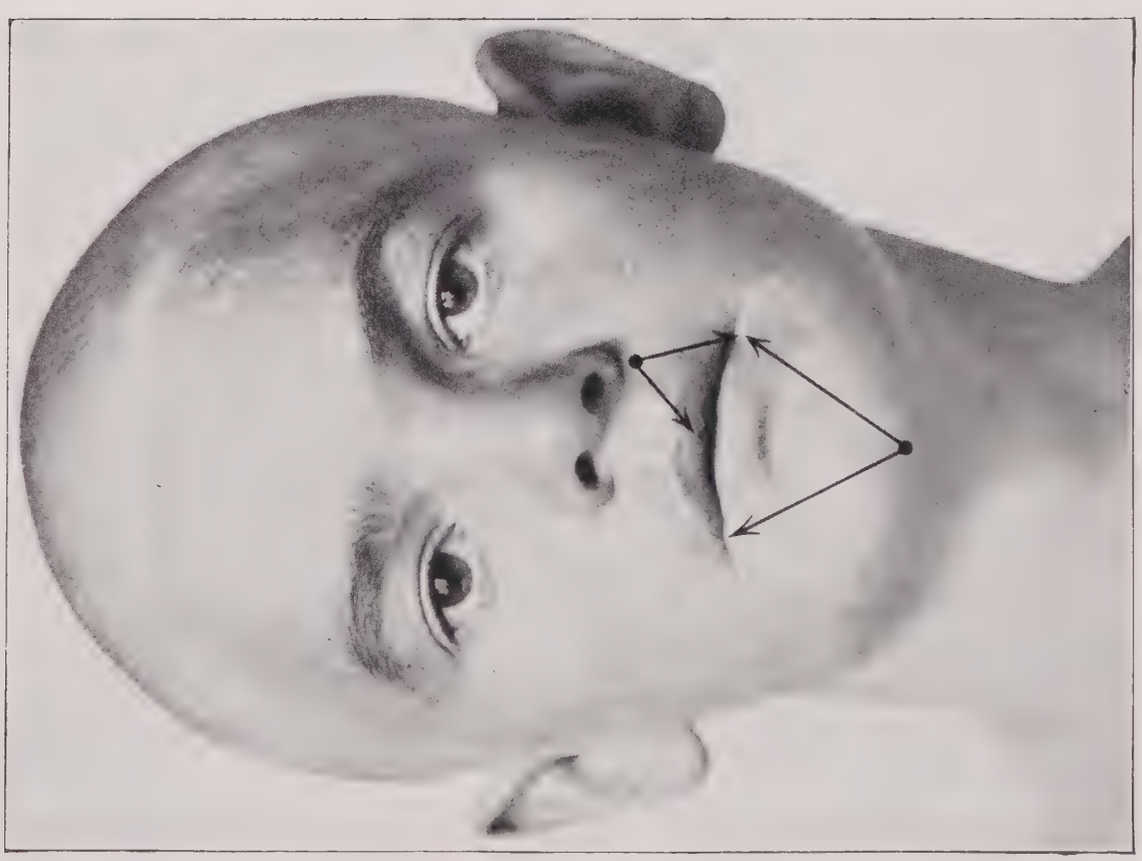

FIG. 22.—Anæsthetizing for upper and lower lip operations.

This procedure is more fully described elsewhere (p. 64). The method given by Braun is briefly as follows: The needle is introduced 1 cm. above and to the side of the lower molar into what Braun calls the trigonum retromolare; it should at once meet with bone. The needle is then guided round the medially situated bony ridge and the lingual nerve is thus reached; if the needle be now pushed deeper for about 2 cm. along the medial surface of the ascending ramus of the lower jaw, the inferior alveolar nerve will be struck. Braun injects 5 c.c. of 1 per cent. novocain-suprarenin solution along the route thus taken by the needle.

DENTAL OPERATIONS.

To obtain the local anæsthesia necessary for dental operations it is as a rule unnecessary to interrupt the conduction of the second and third main branches of the trigeminal nerve at the foramen rotundum and ovale respectively; it will usually suffice to strike the branch in question at a more distal part of its course. In the case of more extensive inflammatory conditions in the alveolar processes, or in extensive extractions, a more central interruption will be almost indispensable.

The sensory fibres that have to be considered in the case of the teeth and gums are derived in the upper jaw from the trigeminus II, in the lower from the trigeminus III. The course and distribution of these branches have already been described; it will therefore suffice if we merely recapitulate briefly. The maxillary nerve which supplies the upper jaw, and which traverses the infra-orbital canal as the infra-orbital nerve and emerges at the foramen of the same name (fig. 24), sends off its sensory twigs to the teeth and gums of the upper jaw partly before entering the bony canal, partly whilst traversing it.

The posterior and median superior alveolar nerves (fig. 24) at first run on the surface of the tuberosity and only pierce the maxillary bone when above the third molar behind the zygomatic process. They supply the upper molars and the gums in the molar region. Somewhat further forward inside the bony canal the anterior superior alveolar nerves are given off (fig. 24), which supply the sensory twigs to the incisors and canines of the upper jaw. By anastomosis with the posterior superior alveolar nerves the superior dental plexus is formed, whose twigs mainly go to supply the bicuspids. The infra-orbital nerve, which emerges by the infra-orbital foramen, likewise sends twigs to the labial surface of the gums.

The hard palate, the lingual gums and the periosteum are innervated by the anterior palatine nerve, which enters the soft tissues

covering the hard palate after emerging from the foramen palatinum majus situated above the third molar. The anterior part of the palate is supplied by the naso-palatine nerve, which emerges from the bone through the foramen incisivum (anterior palatine).

The innervation of the lower jaw is far simpler. The inferior alveolar branch of the trigeminus III furnishes the main innervation;

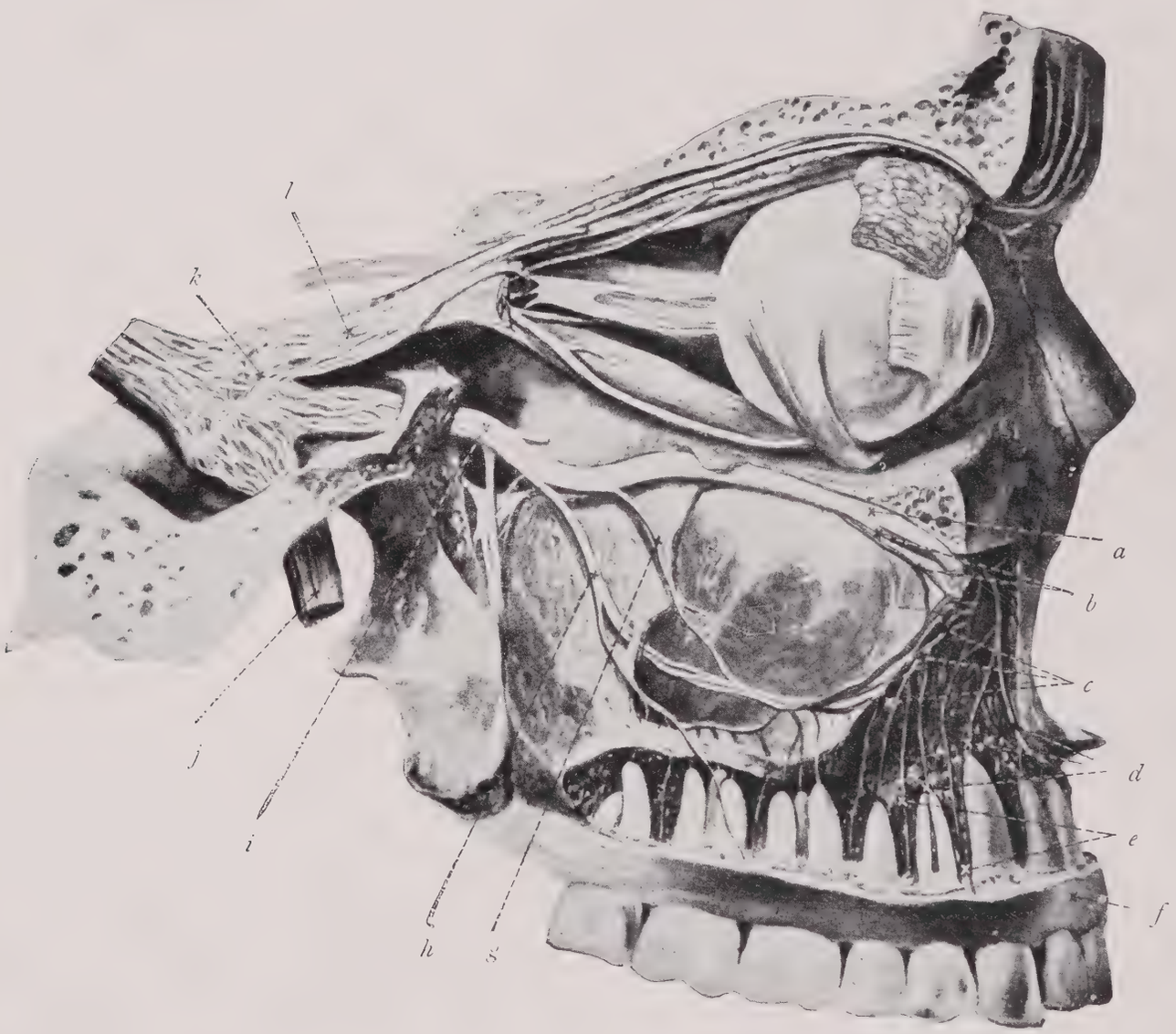

FIG. 24.—(After Spalteholz.) The Second Branch of the Trigeminal Nerve. *a*, N. infra-orbitalis. *b*, Rami alveolares sup. anteriores. *c*, Plexus dentalis sup. *d*, Rami dentales sup. *e*, Rami gingivales sup. *f*, Gum. *g*, Ramus alveolaris sup. medius. *h*, Rami alveolares sup. post. *i*, N. maxillaris. *i*, N. mandibularis. *k*, Ganglion Gasseri. *l*, N. ophthalmicus.

it enters the bone at the lingula, and as it passes through the canal divides into numerous twigs, which form the inferior dental plexus near the roots of the teeth.

From this plexus the dental branches are given off which reach the pulp and the periodonteum, as well as gingival twigs which pierce the bone and reach the gums. The termination of the inferior alveolar nerve leaves the mental foramen as the mental nerve below the first or second bicuspid, and innervates the skin over the chin, the

lower lip and its mucous membrane, the labial gums and the anterior part of the periosteum.

The gums on the lingual side and the periosteum of the jaw are supplied by the lingual nerve (fig. 25).

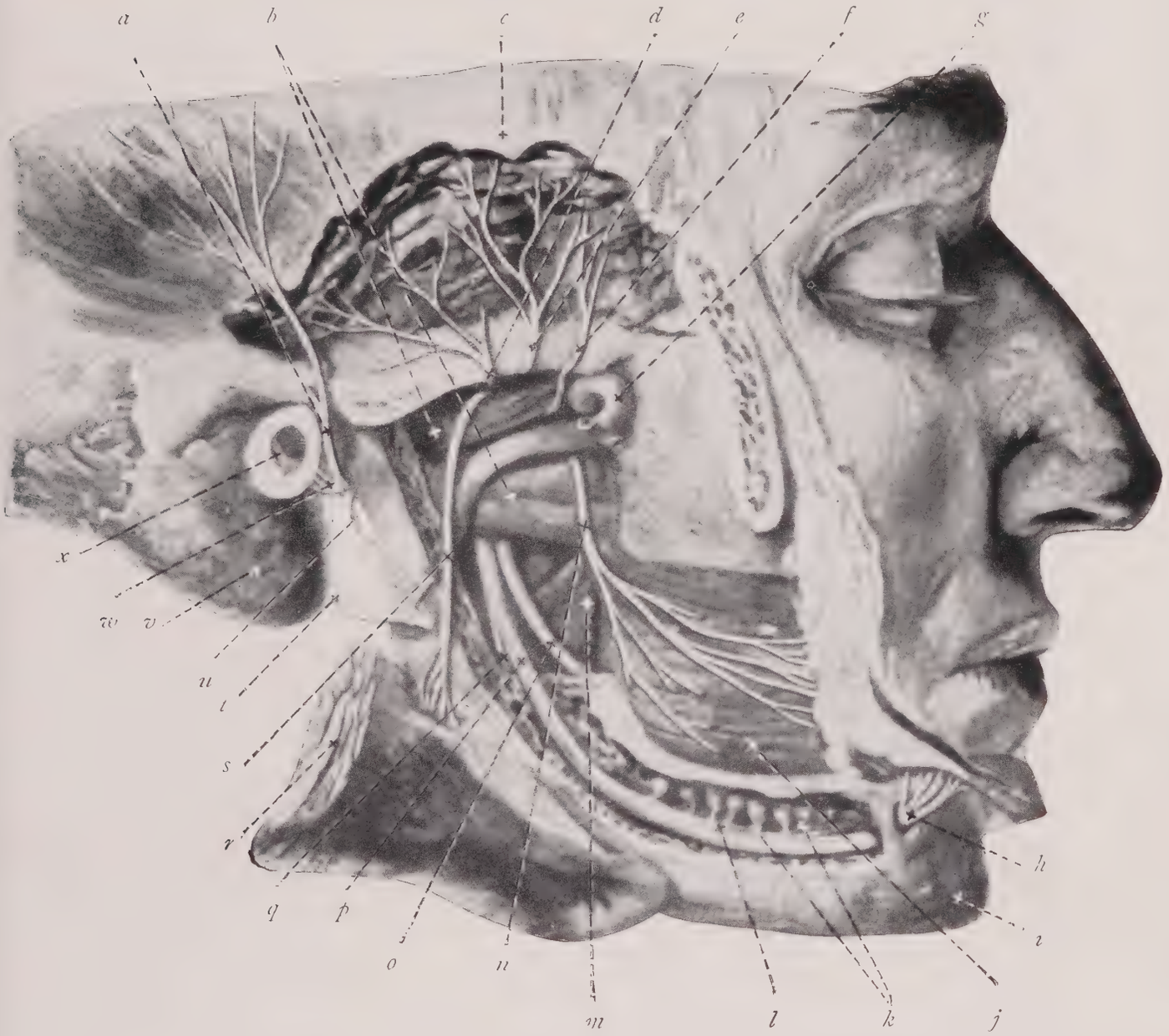

FIG. 25.—(After Spalteholz.) The Third Branch of the Trigeminal Nerve. *a*, N. auriculo-temporalis. *b*, M. pteryg. extern. *c*, M. temporalis. *d*, N. temporalis profundus post. *e*, N. temporalis profundus med. *f*, N. temporalis profundus ant. *g*, Arteria maxillaris interna. *h*, N. mentalis. *i*, Mandibula. *j*, M. buccinator. *k*, Rami dentales inf. *l*, Plexus dentalis inf. *m*, M. pteryg. intern. *n*, N. buccinatorius. *o*, N. lingualis. *p*, N. alveolaris inf. *q*, N. mylohyoideus. *r*, M. masseter. *s*, N. massetericus. *t*, N. facialis. *u*, Rami anastomotici n. facialis. *v*. Processus mastoides. *w*, N. meatus acustici externi. *x*, N. auriculo-temporalis.

The syringe employed for anæsthetic purposes in dental operations differs somewhat from that commonly used for surgical purposes. It should be both smaller and lighter; as it need only hold from 1 to 2 c.c. it may be considerably smaller than the usual syringe of 5 c.c. capacity. The needles are shorter and rather thicker as they are mainly used for sub-periosteal infiltration, in which considerable

pressure is at times necessary. For this reason the handle of the piston is provided with a crutch-like attachment on which the ball of the thumb can be conveniently placed, counter pressure being obtained by means of two finger plates attached to the body of the syringe.

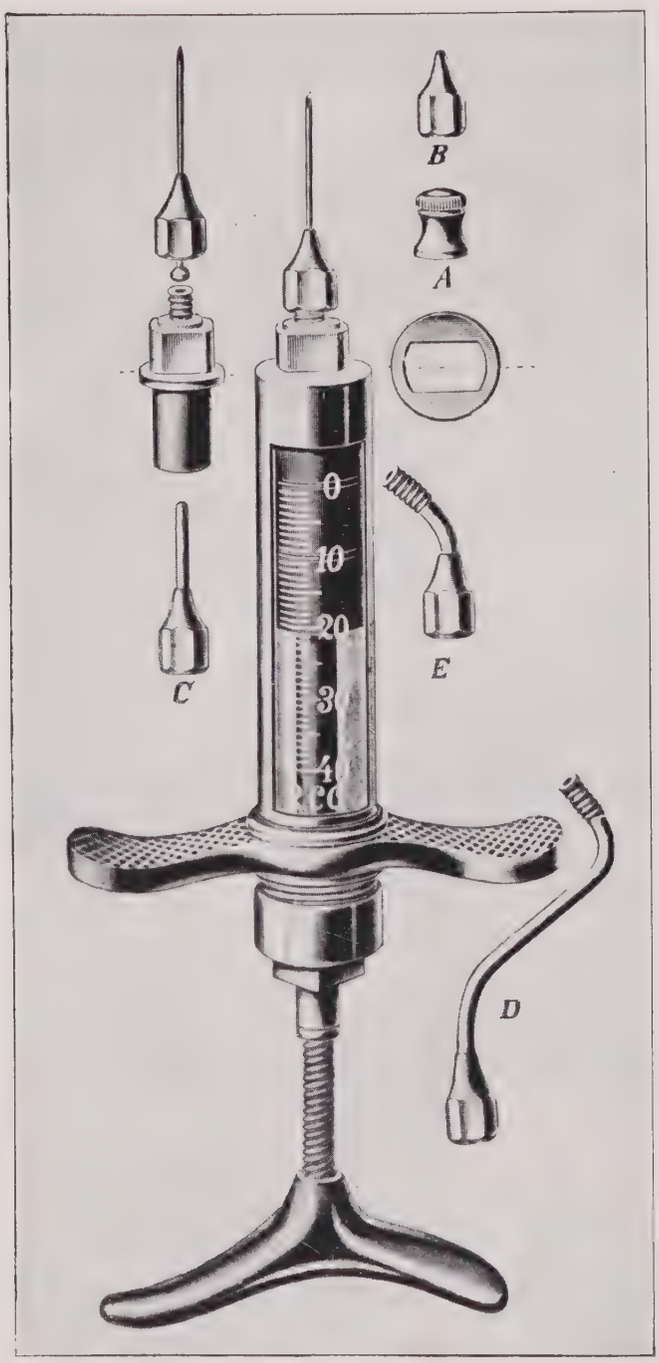

FIG. 26.—Syringe for dental anæsthesia. (Fischer.)

A syringe of this type, that recommended by Guido Fischer, is shown in fig. 26. It is constructed of metal and glass, in such a manner that it can be easily taken to pieces as well as sterilized by boiling. It is provided with several needle attachments of different forms (B-E). The attachment A serves the purpose of closing the nozzle when the syringe is not in use. By this means shorter or longer needles can be used according to the requirements of the case. Fischer recommends needles 23, 26, and 42 mm. long; the points are short, which renders the needles more suitable for anæsthetizing bone, as they are not so liable to get hooked up by the point. According to Fischer one should as far as possible always employ fresh needles, because needles that have once been used, especially if they have not been properly dried, are liable to break. Fischer keeps his syringe in an upright vessel containing absolute alcohol; after use hot water is drawn up several times into the syringe which is then emptied, dried, and after the attachment A has been adjusted, is placed in absolute alcohol.

Should a syringe of this kind not be available, the ordinary syringe used for surgical cases, or even an ordinary Pravaz syringe, may be used.

Fischer recommends the application of a compressing band devised by him round the neck of the patient before proceeding to the induction of local anæsthesia; this consists of a broad rubber band which can be applied with varying degrees of pressure by means of eyes attached to it. Only slight congestion of the face manifesting itself as a slight blush should be induced; all deeper reddening or blueness should be avoided. The advantages of this procedure are, according to Fischer, firstly, diminished rate of absorption and hence greater certainty of successful anæsthetization; secondly, diminished risk of intoxication, and finally, the prevention of fainting attacks due to anæmia of the brain.

For disinfecting the mucous membrane Fischer employs tincture of iodine. In order that the latter may exert its action more deeply Fischer does not merely paint it on the mucous membrane, but rubs it on gently with swabs.

In the case of local anæsthesia for dental operations also we have the two alternatives of infiltration or conduction-anæsthesia. Fischer calls the former mucous membrane anæsthesia.

As we shall see, infiltration-anæsthesia is not applicable in all cases. Whereas it suffices for the upper jaw it often fails in the case of the lower. This fact is dependent on the anatomical conditions, the bony layer of the alveolar border, especially of the molars, being so thick that it hardly permits of diffusion of the anæsthetic taking place. Especially in the lower jaw, then, infiltration-anæsthesia may fail us, and we will have to depend on conduction-anæsthesia.

In the case of operations on the upper teeth, on the other hand, infiltration may still be used in most instances, as it is easier to carry out and more certain to lead to the desired result. It is thoroughly adequate for minor dental operations, extractions, &c., performed on the upper jaw.

Conduction-anæsthesia of the trigeminus II requires, as we have seen above, an exact anatomical knowledge of the sensory distribution of the second branch of the trigeminal nerve, as well as of the localization of the foramen rotundum. Further, a certain amount of practice in the use of local anæsthesia is requisite if the nerves are to be anæsthetized with anything like certainty at the base of the skull. As we shall presently see, the branches of trigeminus II which supply the three upper molars with sensory twigs, the Nn. alveolares sup. post., can be put out of action with ease at the maxillary tuberosity by means of conduction-anæsthesia. As a rule, however, infiltration-anæsthesia of the mucous membrane of the upper jaw is amply sufficient.

The following figures, which are taken from Guido Fischer's work, show the technique of infiltration-anæsthesia on the jaws in a typical manner.

Fig. 27 shows the method of inducing infiltration-anæsthesia in the mucous membrane above the **left upper canine.** The reason for the procedure is supposed to be an abscess above this tooth. It will be noted that the point of introduction of the needle is above the incisor. The syringe is held like a pen and the point of the needle is pushed through the mucous membrane into the periosteum. A certain amount of pressure is required for the injection, and the needle can be pushed onwards under the periosteum in the direction of the other teeth according to the requirements of the operation, the axis of the needle being parallel to that of the teeth. Fischer

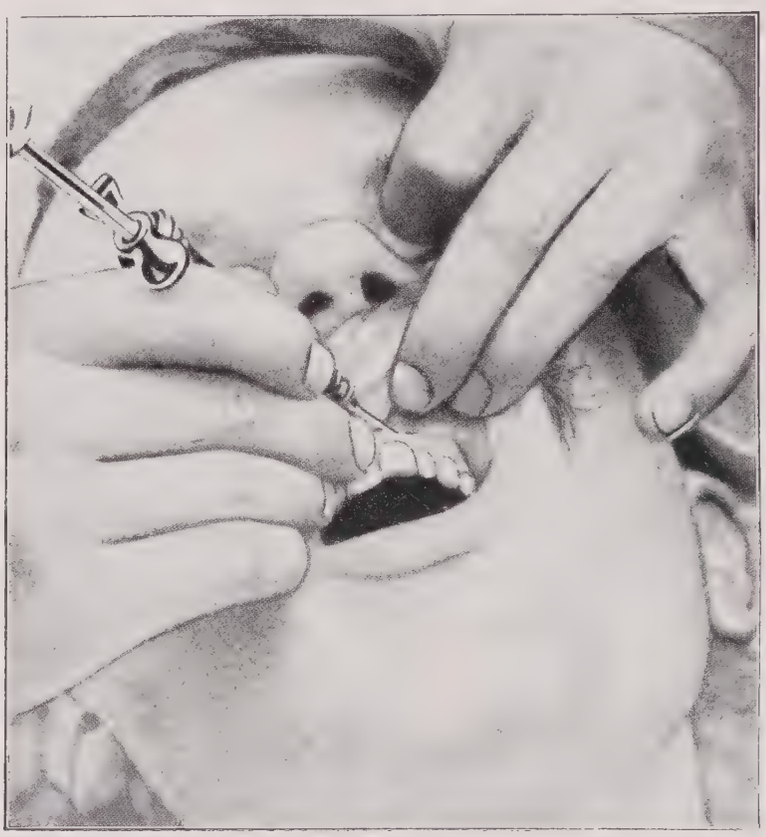

Fig. 27.—(After Fischer.) Injecting the mucous membrane over the upper jaw.

advises compression of the point of puncture with the finger for about a quarter of a minute after removing the syringe; 0·5 to 1 c.c. of 1 per cent. novocain-suprarenin solution should suffice.

In this manner the injection may be easily carried out on the **buccal side** of the upper jaw. As a rule a single point of puncture will suffice: the needle being pushed onward under the periosteum, injecting the fluid as one proceeds if several teeth have to be dealt with. The injection should be made at the level of the middle of the roots of the teeth. The ridge formed below the canines by the bone may cause slight difficulty when the needle is introduced, but this is easily overcome if the needle be introduced at the point of the root and the injection made there.

On the **palate side** of the upper jaw (fig. 28) the needle is introduced behind the tooth that is to be rendered insensitive, and gradually pushed onwards parallel to the alveolar process injecting as one proceeds towards the point of the root. About 0·5 c.c. of 1 per cent. novocain-suprarenin solution will be sufficient.

This palatine method of injection can be employed with ease in the case of all the upper front teeth, including the bicuspids; it is easier to perform and less pressure is necessary when injecting.

FIG. 28.—(After Fischer.) Injecting the mucous membrane from the palate side.

In dealing with the **upper molars** from the palate side it is simpler to interrupt the conduction of the anterior palatine nerve which emerges at the anterior palatine foramen. This point is found by introducing the needle about 0·5 cm. inwards towards the palate behind the last molar (fig. 29).

As we have already stated, infiltration-anæsthesia can only be utilized partially in the case of the **lower jaw**; in most cases it will be necessary to produce conduction-anæsthesia of the inferior alveolar and the lingual nerves.

The **lower canines** and **incisors** are rendered insensitive from the **labial side** as follows. Having retracted the lip, the needle is inserted at the level of the root of the canine and then pushed onwards into the deeper tissues obliquely downwards towards the mental fossa of the lower jaw. At this point there are several small apertures through which the anæsthetic can penetrate into the interior of the bone; 1 c.c. of 1 per cent. solution of novocain-suprarenin will suffice for the injection. This procedure will produce anæsthesia of the canine and the two incisors of the same side (fig. 30).

FIG. 29.—(After Fischer.) Palatinal submucous injection near the bicuspids

From the **bicuspids backwards** the needle should be inserted horizontally at the alveolar border and pushed onwards subperiosteally, since it is here that the best diffusion of the solution into the deep tissues may be expected (fig. 31).

On the lingual side the twigs of the lingual nerve have to be put out of action as well. A small quantity of 1 to 1·5 per cent. solution of novocain-suprarenin should be injected behind the incisors, the canine and the first bicuspid. The needle should be pushed onwards

to near the point of the root, in order that the solution may penetrate into the interior of the bone through the small foramina situated near the internal mental spine. It is hardly possible to make the anæsthetic reach the interior of the bone in any other way in these cases because the bony wall of the lower incisors is very thick on the lingual side (fig. 32).

An angular attachment of the needle facilitates the injection considerably, but it is not absolutely indispensable.

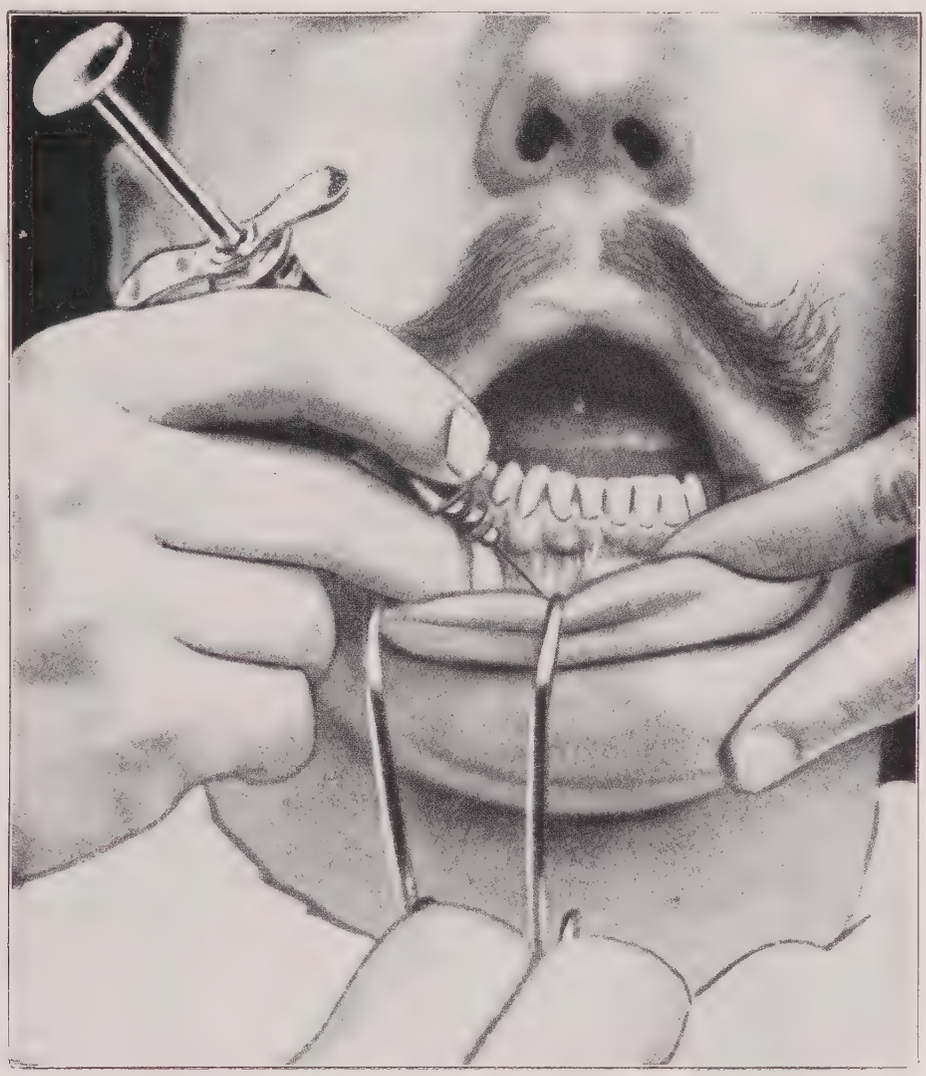

FIG. 30.—(After Fischer.) Anæsthetizing the lower incisors.

The **methods of performing conduction-anæsthesia** commonly employed in dental work, which are sufficient for all purposes, are as follows :—

In the upper jaw there are the injection at the tuberosity of the maxilla and infra-orbital injection ; in the case of the lower jaw there are the mandibular, the lingual and the mental injections.

Injection of the tuberosity is employed for anæsthetizing the three upper molars. By means of it the Nn. alveolares sup. post (fig. 24) are put out of action ; these branches are derived from the

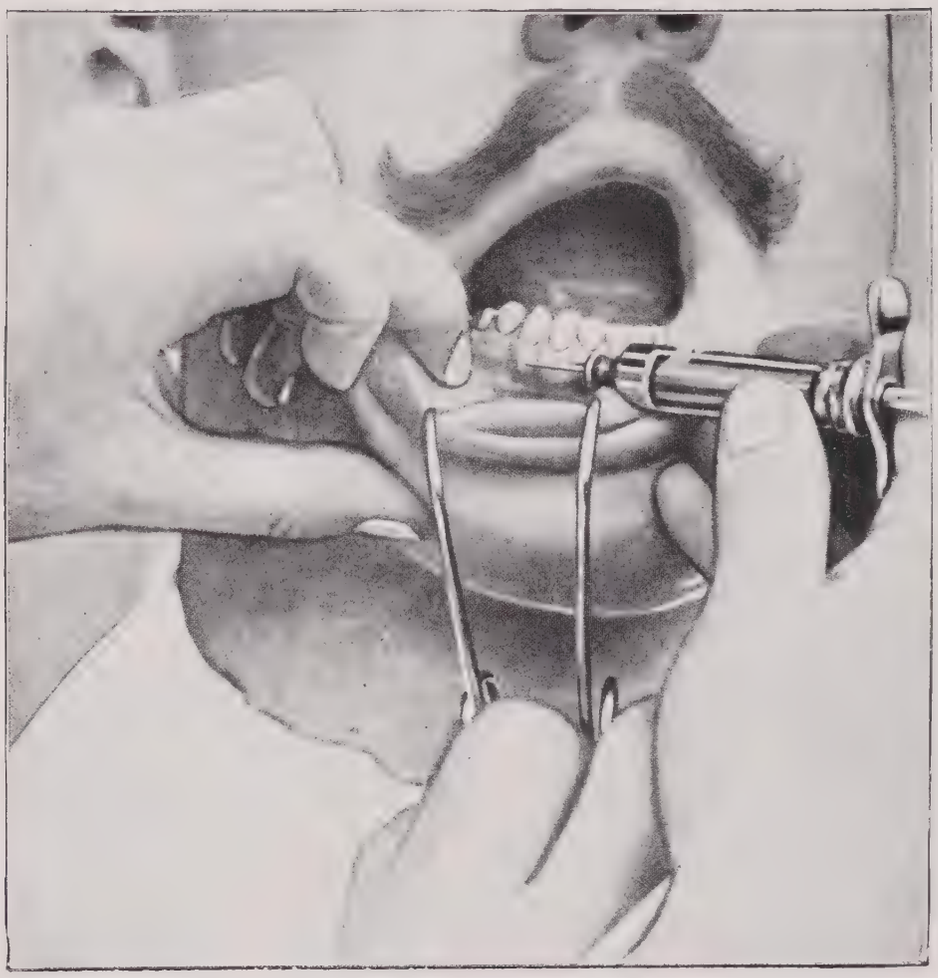

FIG. 31.—(After Fischer.) Anæsthetizing the second lower bicuspid.

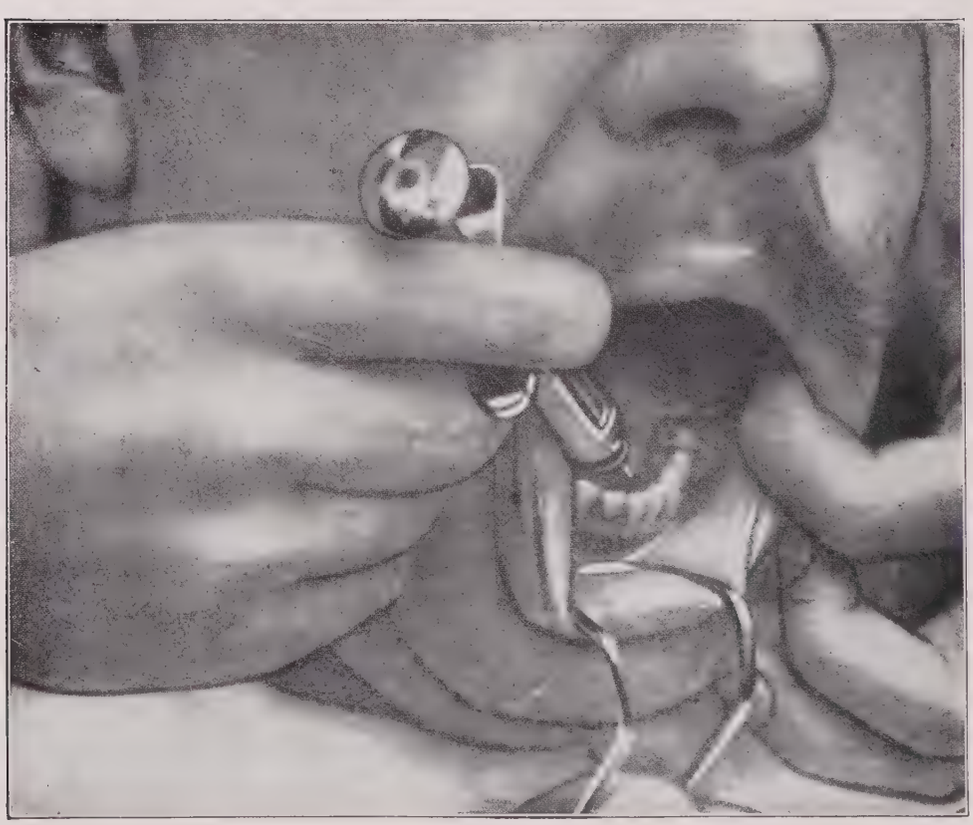

FIG. 32.—(After Fischer.) Injection from the lingual side between the lower canine and bicuspid to anæsthetize the lingual nerve.

maxillary nerve immediately after it leaves the foramen rotundum and enter the alveolar processes by means of numerous small foramina behind the processus zygomaticus (malar process) above the points of the roots of the molars.

The technique of the procedure is as follows : The mouth of the patient should be half-open. The processus zygomaticus (malar process) is then felt for and the cheek drawn upwards. The needle, which should be several centimetres long, is introduced above the first molar into the fold of the reflected mucous membrane rather away

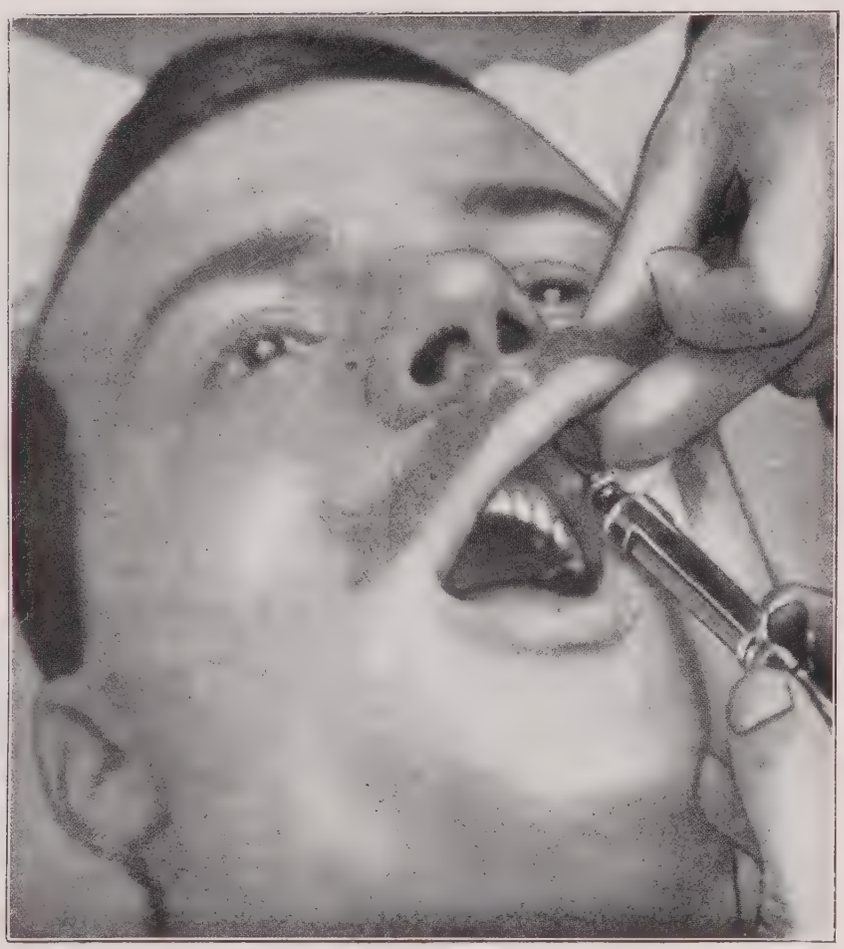

FIG. 33.—(After Fischer.) Conduction-anæsthesia at the infra-orbital foramen.

from the bone and pushed on sloping from behind forward. The needle should be kept as near as possible to the tuberosity ; 1 to 2 c.c. of 1·5 per cent. novocain-suprarenin solution will be sufficient.

To assist complete anæsthesia it is well to perform infiltration-anæsthesia in the mucous membrane on the labial side of the first molar, and to inject the anterior palatine foramen on the palatal side as described above ; 0·5 c.c. of the novocain-suprarenin solution should suffice for this purpose. Anæsthesia will be produced after several minutes.

The object of the infra-orbital injection is to interrupt the conduction of the superior dental plexus formed by the Nn. alveolares

sup. ant. These small nerves branch off from the maxillary nerve (trigeminus II) just before it leaves the infra-orbital foramen and proceed along the inner surface of the wall of the maxilla to the canines and incisors. They can, therefore, only be reached indirectly by the anæsthetizing solution by way of the infra-orbital foramen. The solution must, therefore, be injected in such a manner that it can penetrate through the foramen and reach the nerves lying behind it.

The technique is as follows (fig. 33) : The infra-orbital foramen is compressed with the finger and with the same hand the upper lip is retracted. The foramen is situated $\frac{1}{2}$ cm. below the inferior orbital

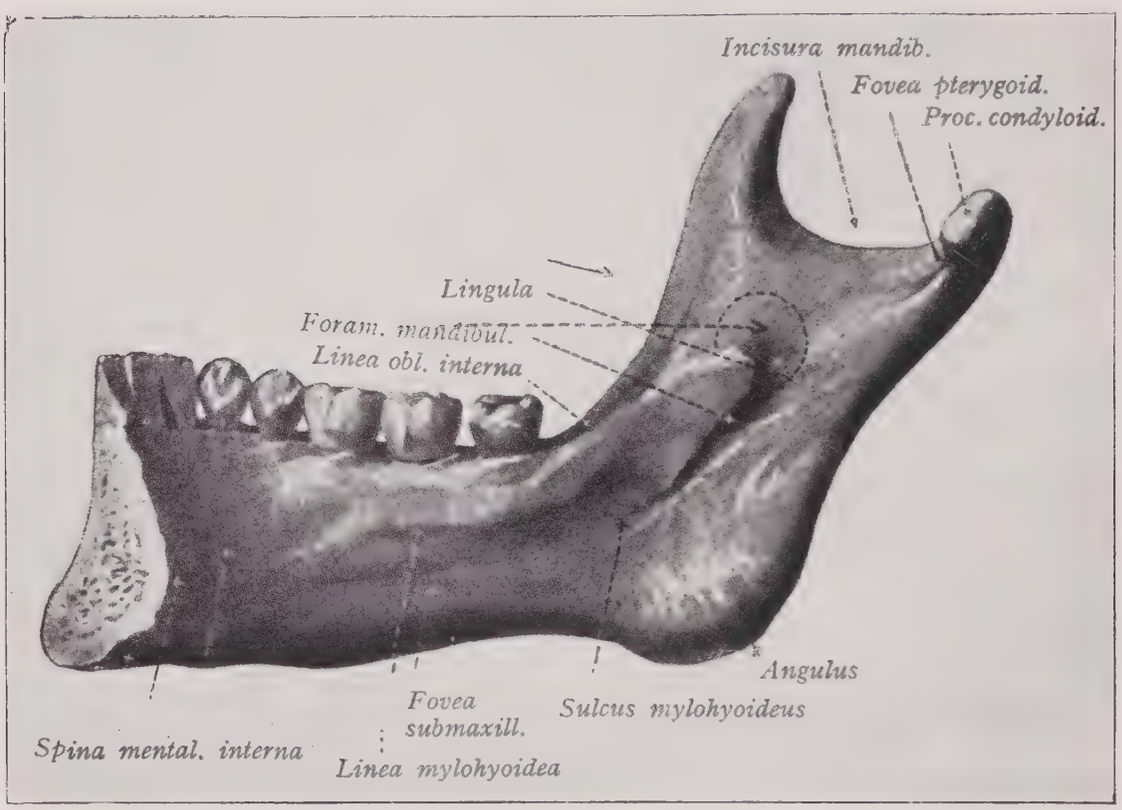

FIG. 34.—(After Fischer.) The internal surface of the lower jaw with the foramen mandibulare.

margin above the first molar. With the other hand the needle is now introduced into the fold of reflection of the mucous membrane behind the canine and pushed onward until the neighbourhood of the foramen under the finger is reached. At this point 1 to 2 c.c. of 1·5 per cent. novocain-suprarenin solution are injected, using fair pressure. Fischer recommends that the area about the infra-orbital foramen should be gently massaged. To this conduction-anæsthesia subperiosteal infiltration-anæsthesia on the palatine side must be added, performed as above described.

Far more important and generally applicable than the two conduction-anæsthesias just described for the upper jaw is the **mandibular anæsthesia** of the lower jaw. For, as we have seen, infiltration-anæsthesia subperiosteally applied suffices for the majority of dental

operations of the upper jaw, whereas it often fails in the lower jaw owing to the anatomical conditions prevailing.

The ascending ramus of the lower jaw ascends almost directly behind the last molar. From the last molar two ridges pass back-

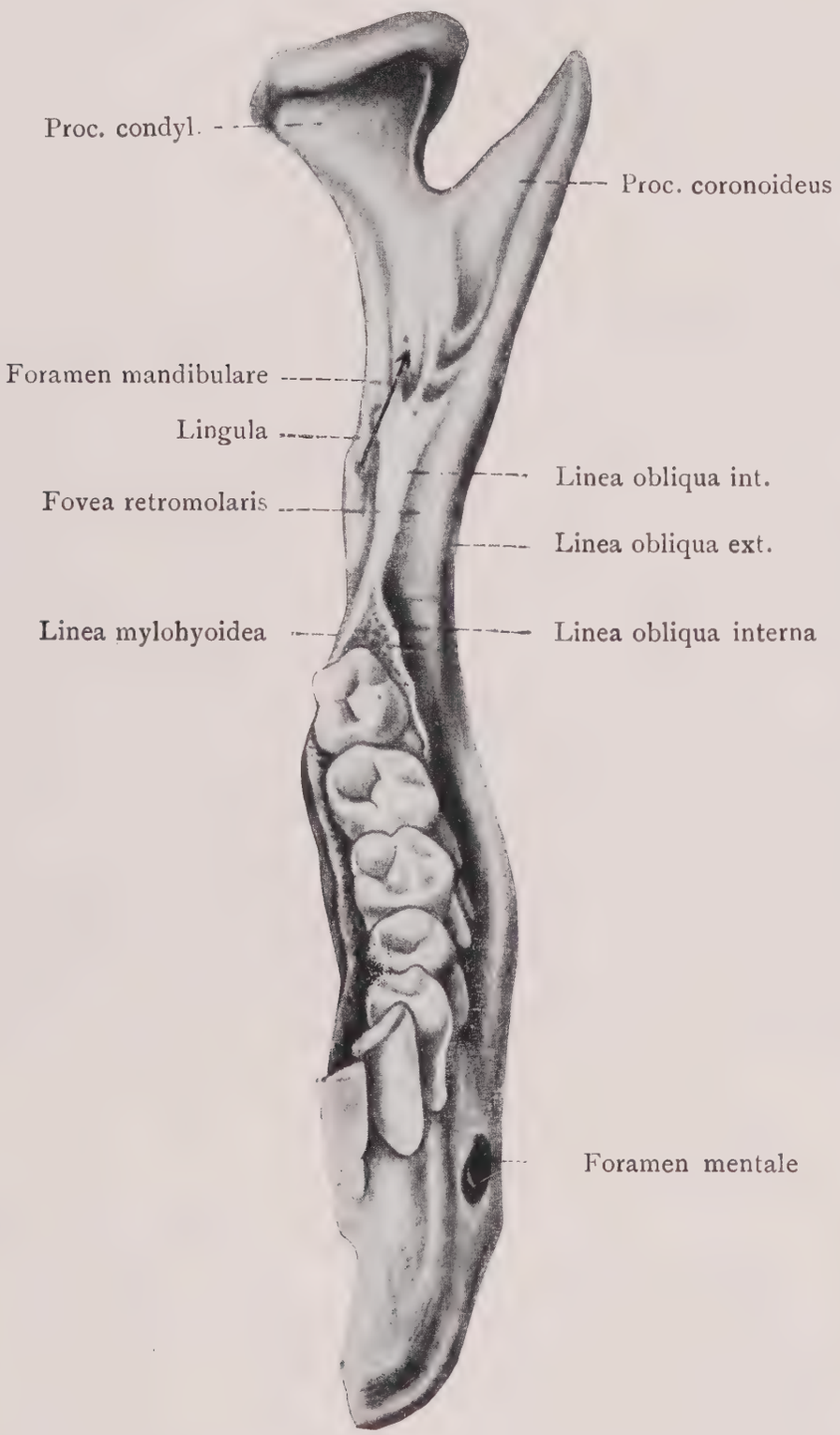

FIG. 35.—(After Fischer.) The lingula and the foramen mandibulare from above. (The arrow shows the direction of the injecting needle.)

wards to the ascending ramus and are there absorbed, the linea obliqua externa and interna (figs. 34 and 35).

Near the middle of the ascending ramus is situated the foramen mandibulare (inferior dental foramen). The entrance to this foramen

is partly covered by a small plate of bone, the lingula. This is very apt to vary in shape. The foramen is situated above the alveolar border, horizontally, distant about 1·5 cm. from the border of the jaw. In the two illustrations (figs. 34 and 35), which are taken from Fischer, the arrow indicates the direction of the needle in performing mandibular anæsthesia.

The first reported instance of mandibular anæsthesia dates back to 1885, and was performed by Raymond with 13 drops of a 4 per cent. solution of cocaine, anæsthesia of the right half of the tongue and lower jaw being obtained after seven minutes. The procedure was

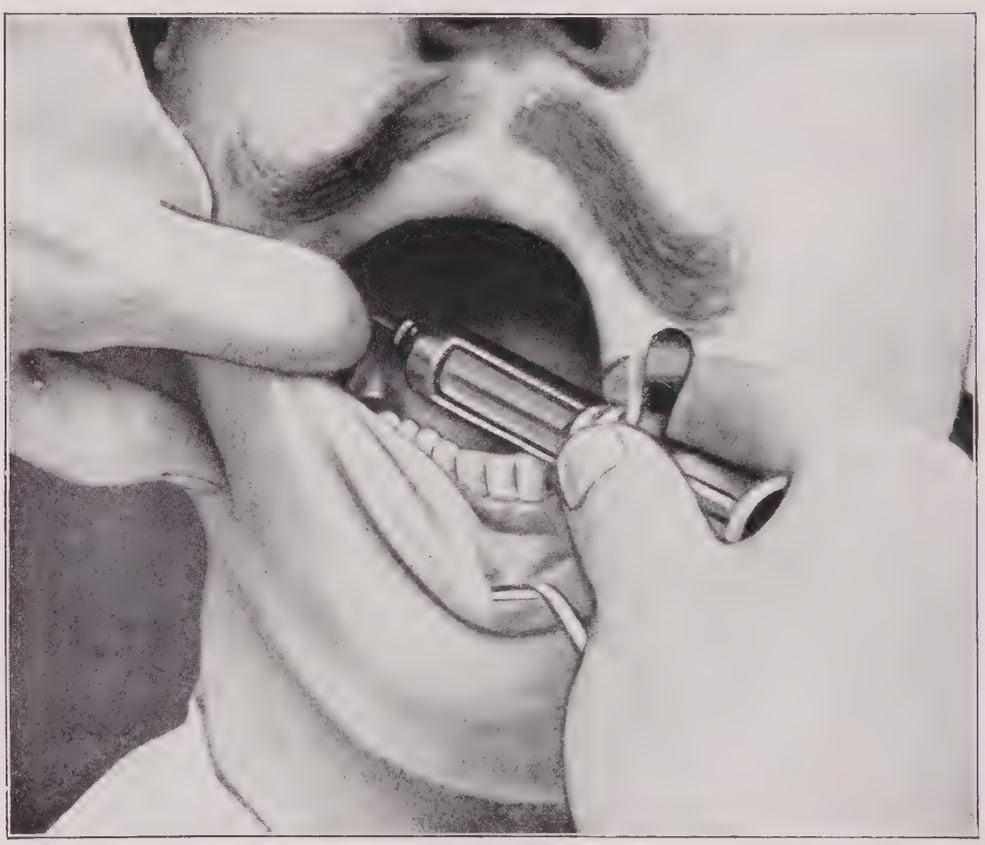

FIG. 36.—(After Fischer.) Mandibular anæsthesia.

uncertain when weak solutions of cocaine were employed, and hence fell into disrepute. Schleich and the dental surgeons, Thiesing, Krichelsdorf, Dill, and Huebner again took it up, using cocaine-suprarènin solutions, and at the present day mandibular anæsthesia is generally known and practised.

The region of the lingula lies in a small depression and not in the axis of the row of the teeth. To strike the foramen mandibulare with the needle this fact must be remembered, the direction of the needle being not parallel to the teeth but parallel to the inner surface of the ramus of the jaw. When the needle is in the right position pointing to the lingula it forms an acute angle with the line of the teeth.

The technique of the injection is as follows : The patient holding

his mouth wide open, the operator introduces the finger of one hand and feels for the ascending ramus of the lower jaw; the two bony ridges, the linea obliqua externa and interna, are easily recognized by palpation. Between these two there is a small depression into which the finger sinks. At this point the mucous membrane is folded in in the form of a triangle, which Braun calls the trigonum retromolare. The needle is introduced in the centre of this triangle 1 cm. above and 1 cm. laterally (external) to the molar surface of the lower teeth. Fig. 37 shows the position of the syringe when performing mandibular anæsthesia. 1 = linea obliqua interna, 2 = linea obliqua externa, 3 = the point at which the needle is inserted about 1 cm. above

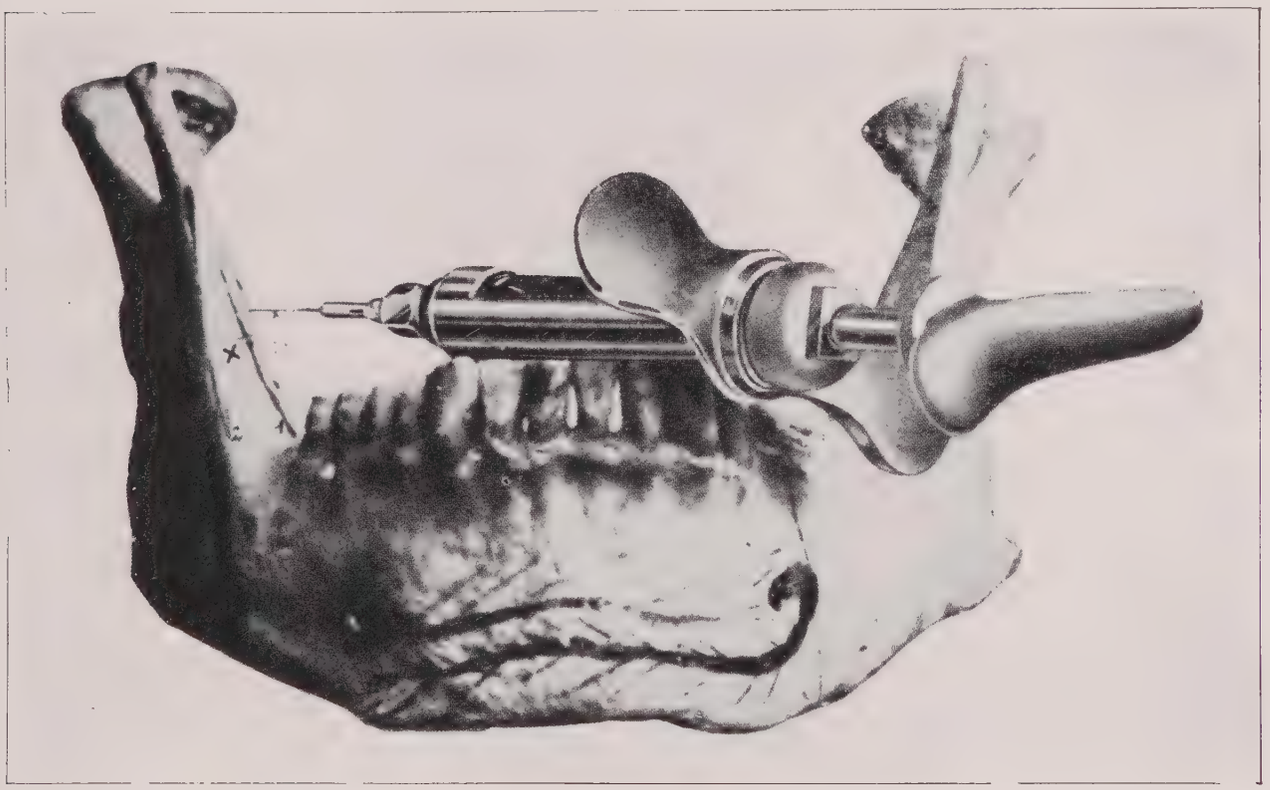

FIG. 37.—(After Fischer.) The position of the syringe for mandibular anæsthesia, viewed from the front.

the molar surface of the teeth; 2 to 3 c.c. of 1 to 2 per cent. solution of novocain-suprarenin suffice, anæsthesia supervening ten to fifteen minutes after the injection, and extending to the teeth as far forwards as and including the first bicuspid. In order to put the buccinator nerve (buccal) out of action further 1 to 2 c.c. of the solution should be injected subperiosteally on the lingual side of the molars. Fig. 38 (Fischer) shows the direction and position of the needle when giving the injection; 1 = linea obliqua externa, 2 = linea obliqua interna, 3 = the position of the needle at the upper margin of the lingula, 4 = the point of the needle and the point up to which the needle must be pushed forward, 6 = the level of the needle 1 cm. above the

molar surfaces of the teeth, 7 = lingula, 8 = foramen mandibulare (inferior dental).

If the **lingual nerve** is to be injected also, as is necessary if complete anæsthesia is to be obtained, the following method should

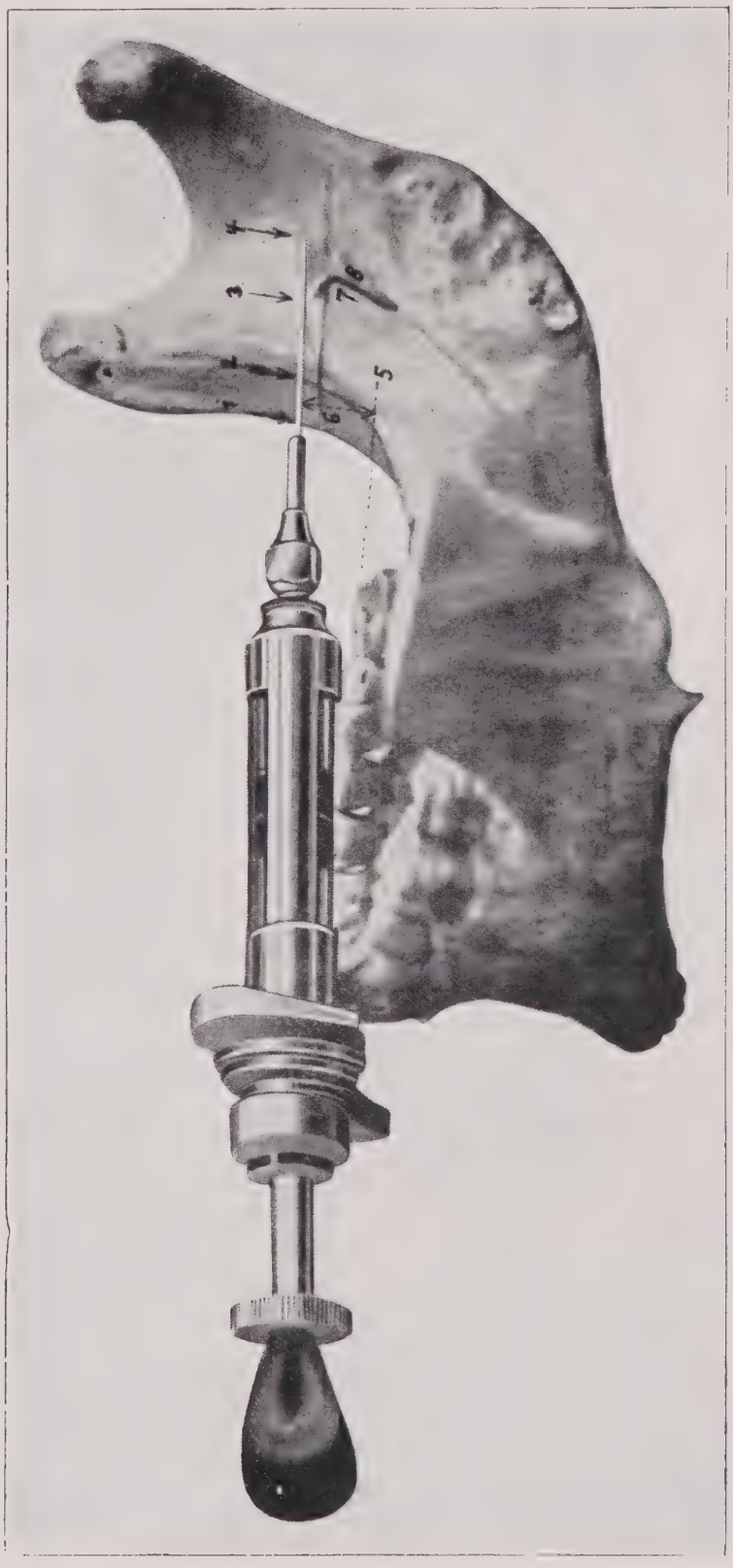

FIG. 38.—(After Fischer.) Position of syringe for mandibular anæsthesia, viewed from the side.

be adopted : The needle is introduced as above described into the centre of the retromolar triangle 1 cm. above and laterally (external) to the molar surface of the last molar. Bone should be struck

immediately below the mucous membrane ; at this point on the linea obliqua interna one strikes directly on the lingual nerve. It is sufficient to inject 5 c.c. of 1 to 2 per cent. novocain-suprarenin solution. By now pushing the needle onwards towards the lingula as above described the mandibular nerve is anæsthetized.

The **mental injection** at the mental foramen is carried out in a manner analogous to that employed at the infra-orbital foramen, the intention being to force the anæsthetizing solution into the mental foramen and the canal. In this case also a fair amount of pressure is necessary for success.

Braun, Schleich, Buente, and Moral point out that this injection puts out of action mainly the anastomosis of the other side. Fischer and Peckert, therefore, anæsthetize the mental nerve of the opposite side to that on which they have to operate. Buente and Moral inject both foramina, if they wish to render the entire front insensitive.

The main object of mental anæsthesia is to put the anastomosis of the opposite side out of action. Thus, for instance, when operating on the left half of the lower jaw, anæsthesia of the mandibular is performed on the right, and mental on the left side, and conversely when the left jaw is being operated on.

Technique of the procedure : The needle is introduced into the fold of reflection of the mucous membrane near the second bicuspid and pushed downwards under the periosteum for a few millimetres towards the point of the root. The foramen is situated below the points of the roots between the two bicuspids ; 1 to 2 c.c. of 1 to 2 per cent. novocain-suprarenin solution are injected.

OPERATIONS ON THE TONGUE.

Smaller tumours or ulcers of the tongue may be removed by infiltrating wedges from the margin of that organ. If incisions have to be performed nearer the base of the tongue, the injection should circumscribe the field of operation in the form of a rhomboid.

It is a different matter when one has to deal with more extensive resections or extirpation of the tongue. In such cases conduction-anæsthesia of the **lingual nerve** must be undertaken by the above mentioned method, either on one or on both sides.

The posterior part of the tongue and the tonsils are supplied with sensory nerves from the **glosso-pharyngeal nerve.** This must therefore also be put out of action whenever the operation extends to the root of the tongue and tonsils (fig. 39).

Braun describes the following procedure for this purpose : The needle is introduced at the point *c* (figs. 39 and 40), which is situated medially over the hyoid bone, and the point being guided by the left

index finger introduced into the mouth, is pushed over the epiglottis, infiltrating transversely from one palatine arch to the other.

In addition to the anæsthetizing of the glosso-pharyngeal nerve the tongue is rendered bloodless by this procedure, so that ligature of the lingual artery is rendered unnecessary.

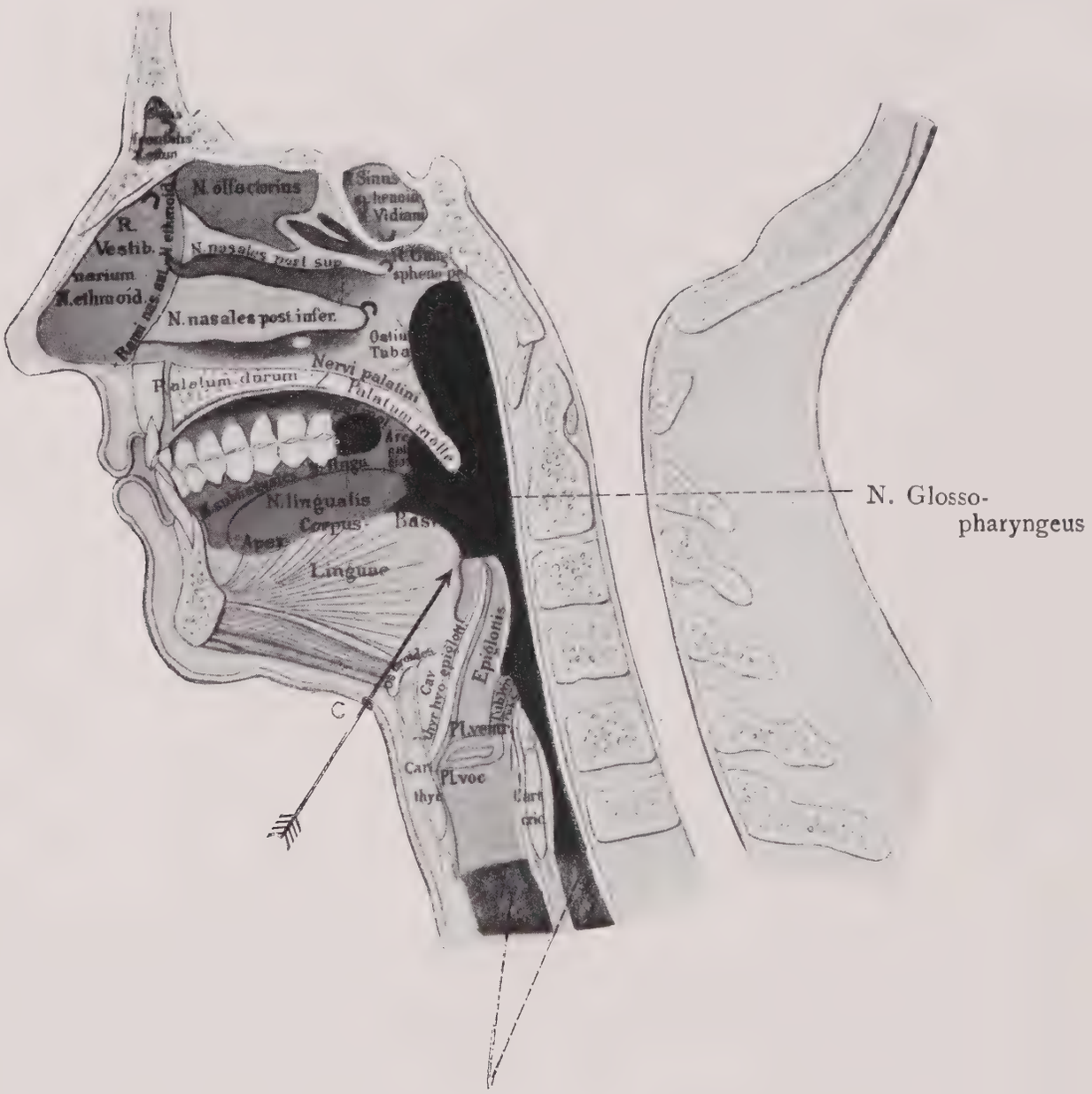

FIG. 39.—(After a figure by Hasse.) The sensory innervation of the mouth, jaws, pharynx, and larynx. At point *c* the needle is introduced for Braun's anæsthetizing method for the N. glosso-pharyngeus.

For operations on the **tongue and floor of the mouth** involving median splitting of the lower jaw, Braun suggests the method of injection represented by fig. 40. In addition to lingual injection and anæsthetization of the Nn. alveolares inferiores at the lingula, the glosso-pharyngeal nerve must also be anæsthetized at the point *c* as above described. Further, the field of operation must be circumscribed by subcutaneous injection as shown in fig. 40.

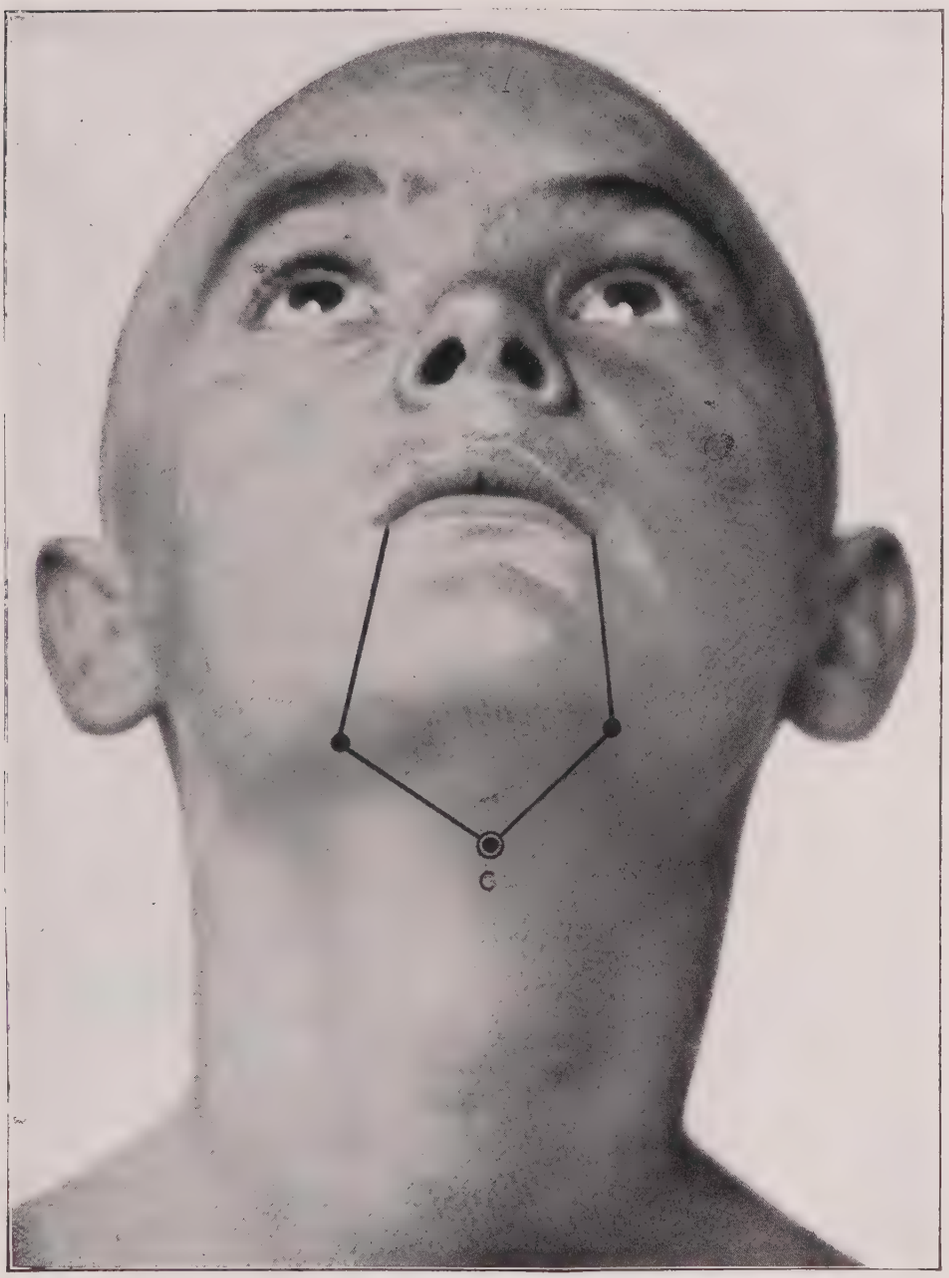

FIG. 40.—Anæsthesia for operations on the tongue and floor of the mouth, according to Braun.

OPERATIONS ON THE LOWER JAW.

The technique of injection for anæsthetizing the lower jaw at the lingula has been described sufficiently on pp. 64-66. This may be employed unilaterally or bilaterally for wiring fractures of the lower jaw, for temporarily sawing through the same, or for excisions and resections. As it is frequently necessary when performing operations on the lower jaw to remove neighbouring tissues and glands in the neck simultaneously, Braun has suggested a method of procedure which is represented in fig. 41. Supposing a carcinoma of the alveolar process of the left lower jaw has to be removed. The lingula is injected on both sides, and the field of operation is circumscribed by injection as indicated in fig. 41. To reduce the

hæmorrhage Braun injects in addition towards the floor of the mouth from a point situated near the margin of the jaw using 0·5 per cent. novocain-suprarenin solution. After such an injection a piece of the lower jaw, as well as the submental and submaxillary lymphatic glands, can be removed painlessly. In such resections of the lower jaw, Hohmeier adds circumscribing injections of the lower jaw

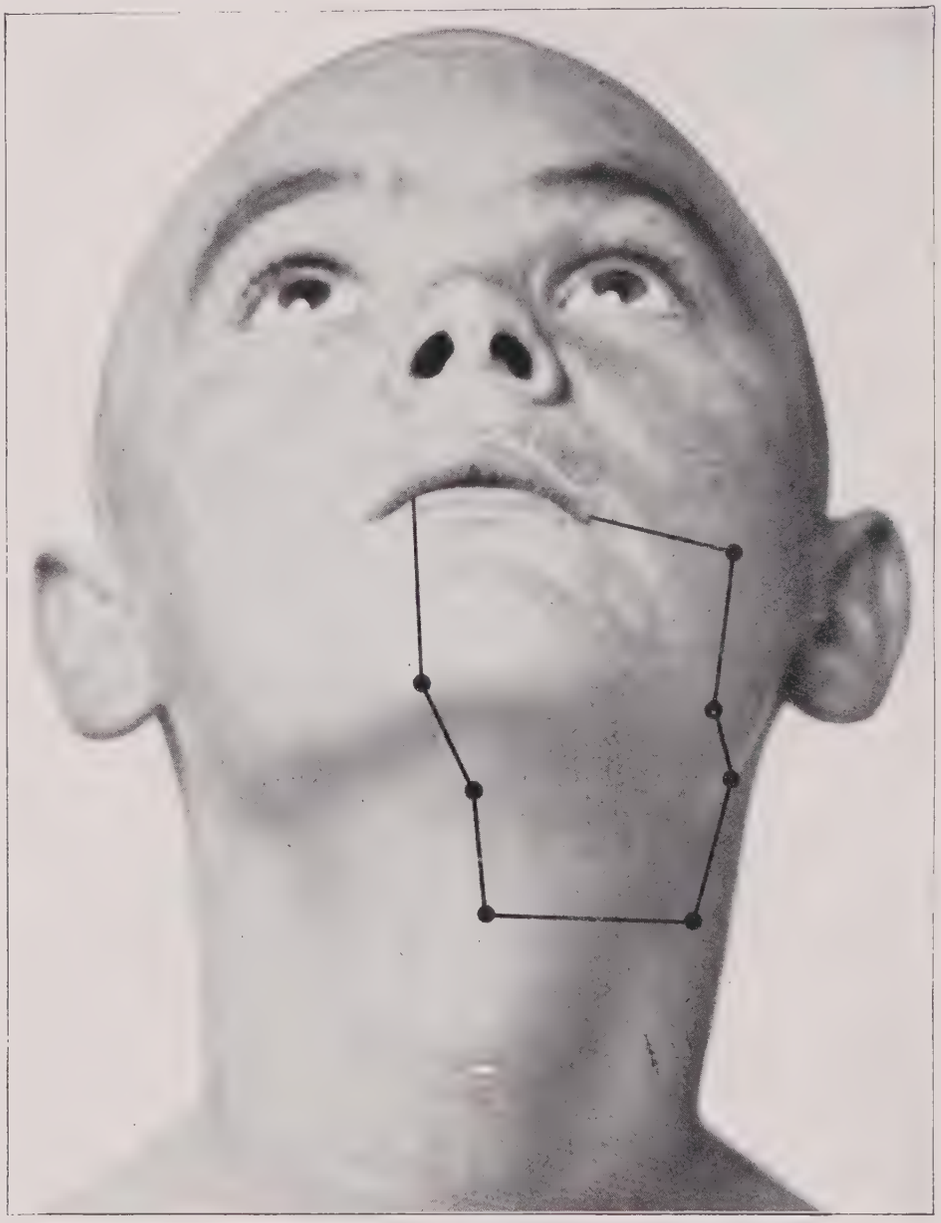

FIG. 41.—Circum-injection of the field of operation for lower jaw and neck, according to Braun.

and floor of the mouth extending over the whole field of operation, in order to obtain absolutely certain anæsthesia. This seems unnecessary if the lingual injection has been satisfactorily performed.

Local anæsthesia is also easily induced for operations which involve the tonsillar regions and the posterior part of the tongue, and for such as involve a temporary resection of the lower jaw in which an incision has to be made inclined backwards from the angle

of the mouth across the lower jaw to the sterno-cleido-mastoid (v. Langenbeck).

For such cases mandibular and lingual anæsthesia should be induced at the lingula; then the soft parts should be infiltrated along the line of incision from the angle of the mouth in a curved direction backwards over the lower jaw to the sterno-cleido-mastoid. Further, the glosso-pharyngeal nerve, which supplies the root of the tongue, should be put out of action, and perhaps also the vagus, which supplies the fossa glosso-epiglottica.

Anæsthesia extending as far as the tonsils cannot be induced by the above mentioned method of Braun. Hohmeier overcomes the difficulty by injecting the base of the tongue, inserting the needle several times in a direction from above and in front backwards and downwards, after drawing the tongue forward forcibly.

Hirschel has described a method by which the glosso-pharyngeal nerve and the vagus can be anæsthetized simultaneously; this procedure will be described later. The author has found it of great service in the above tonsillar operations.

OPERATIONS ON THE PALATE, PHARYNX, AND ŒSOPHAGUS.

For operations on the palate, more especially splitting the palate, infiltration-anæsthesia along the margins of the fissuring incision, and in the region in which the additional incisions may be made, suffices. At the same time it renders the parts bloodless. Local anæsthesia in splitting the palate can probably only be used in the case of adults.

Local anæsthesia for operations on the root of the tongue and tonsils has already been mentioned in part. Laryngologists usually induce anæsthesia of the tonsils for tonsillectomy by injecting under and round the tonsil from several points a little removed from that organ. The method mentioned by Braun and Hohmeier, of putting the glosso-pharyngeal nerve out of action at the base of the tongue and near the tonsils, will only suffice when the operation does not extend to the velum and pharynx. If this be the case, the glosso-pharyngeal nerve must be interrupted in its main trunk. As the vagus supplies the epiglottis and the fossa glosso-epiglottica, the vagus may also have to be anæsthetized where the operation is likely to extend to this area.

From fig. 39 it will be seen that the whole pharynx, the root of the tongue and the tonsils are supplied by the glosso-pharyngeal nerve, whereas the entrance to the larynx, the larynx and œsophagus are

supplied by the vagus. Both these nerves may be reached simultaneously by the needle at the point where they emerge from the skull through the foramen jugulare (fig. 42).

The method given by Hirschel is as follows : Having made a preliminary infiltration wheal at the point of introduction, the long fine needle is introduced at the posterior border of the mastoid process, at the anterior border of the sterno-cleido-mastoid.

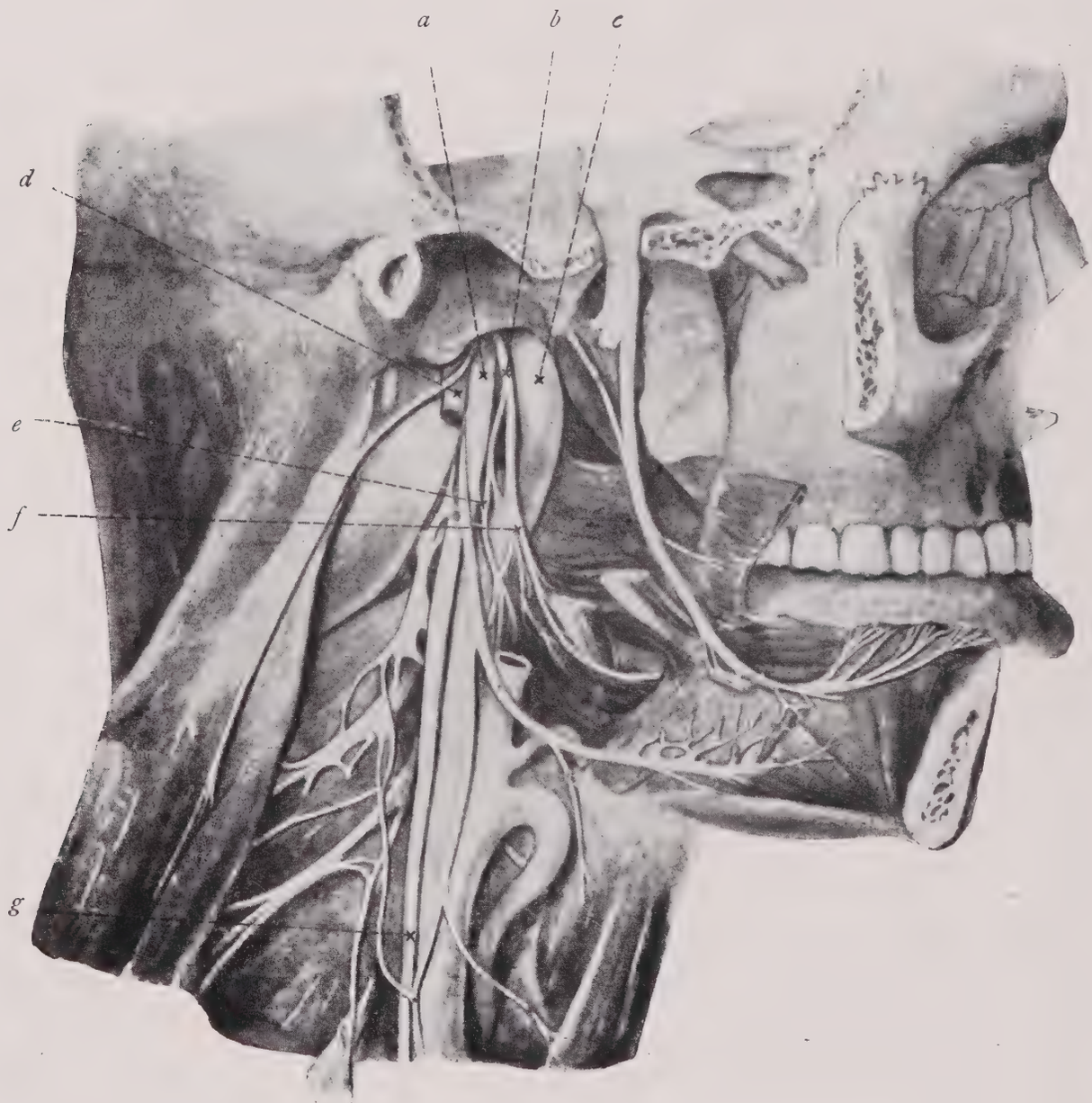

FIG. 42.—(After Spalteholz.) Position of the vagus and glosso-pharyngeal nerves after emerging from the foramen jugulare. *a*, N. vagus. *b*, N. glosso-pharyngeus. *c*, A. carotis interna. *d*, V. jugularis interna. *e*, Rami pharyngei n. vagi. *f*, Rami pharyng. n. glosso-pharyng. *g*, N. vagus.

The direction of the axis of the needle is that of the transverse axis of the skull, perhaps slightly inclined forward. Passing the styloid process the needle reaches the occipital condyle. The needle has now reached a depth of about 3·4 cm. In this region some 10 c.c. of 2 per cent. solution are injected, being distributed a little so that as much tissue as possible may be infiltrated by the anæsthetic. By

so doing it is possible for the solution to penetrate into the rather thick nerve-trunks, even if they be not actually struck by the needle. The point of insertion of the needle is marked *a* in fig. 43.

According to the incision selected for the extirpation of the pharyngeal cancer, either along the anterior border of the sterno-cleido-mastoid downwards, or more inclined towards the lower jaw, the subcutaneous tissues and muscles should be anæsthetized by infiltration, using several syringefuls of 0·5 to 1 per cent. solution of novocain-suprarenin. By this means the conduction of the lateral

FIG. 43.—Anæsthetizing the vagus and glosso-pharyngeal nerves.

cutaneous nerves of the neck and the great auricular nerve is interrupted (fig. 43).

Since in most cases a temporary resection of the lower jaw will have to be undertaken simultaneously, this glosso-pharyngeal vagus anæsthesia will have to be combined with that of the trigeminus III, and if the palate should also be involved in the field of operation that of the trigeminus II as well. Both procedures have already been described.

This glosso-pharyngeus vagus anæsthesia is also required in operations on the œsophagus.

As may be seen from fig. 39, the glosso-pharyngeal nerve supplies the entire pharynx down to the lower border of the cricoid cartilage; from here downwards it is replaced by the recurrent branch of the vagus, the larynx and the entrance to the larynx being supplied by the superior laryngeal branch of the vagus.

Whether the glosso-pharyngeal nerve is to be anæsthetized together with the vagus or not is immaterial from a practical point of view, for both nerves are invariably affected by the anæsthetic.

The author has only had occasion to use this vagus anæsthesia once, in a case of œsophageal cancer situated laterally in the cervical portion. Subcutaneous infiltration of the area of the skin incision by means of 1 per cent. novocain-suprarenin solution was added to the procedure. The anæsthesia was very satisfactory.

OPERATIONS ON THE EAR.

The nerves mainly to be considered in connection with the **outer ear** are the great auricular and the small occipital nerves and the auriculo-temporal branch of the trigeminus III (fig. 44).

It is unnecessary to interrupt the conduction in these nerves for operations on the auricle, circum-injection according to Braun's method being quite adequate.

Starting from two points (1 and 2 in fig. 45), which should be indicated by wheals, 1 per cent. solution of novocain-suprarenin is injected subcutaneously in the directions indicated by the arrows, so that both arrows meet. The same is then done at the back of the auricle, which is drawn forward for the purpose by the left hand. A few cubic centimetres of 0·5 to 1 per cent. solution are sufficient. In addition a few more may be injected deeply from point 2 between the mastoid process and the condylar process of the lower jaw so as to interrupt the few branches distributed by the vagus in this region.

In **minor operations on the auricle,** extirpations of small tumours, &c., it is sufficient to circumscribe the segment in question by injections in front and behind (fig. 45 *a*, *b*, and *b*, *c*, *d*).

The innervation of the **internal ear** is rather complex.

The outer part of the auditory canal, the meatus acusticus cartil., is supplied by the auriculo-temporal nerve, trigeminus III; the next section, the meatus acusticus osseus, by the auricular branch of the vagus; the tympanic membrane by the vagus and trigeminus III; the ossicles by the glosso-pharyngeal nerve.

Attempts to anæsthetize the internal ear have been made by Braun and Neumann.

The **procedure of Neumann** is as follows (according to Braun): The needle is introduced into the upper wall of the cartilaginous part of the meatus about 0·5 to 1 cm. from the commencement of the bony part, and pushed on under the periosteum. The junction of the cartilaginous and the bony parts of the meatus may be found by moving the auricle. It is indicated by a fold. The needle is pushed

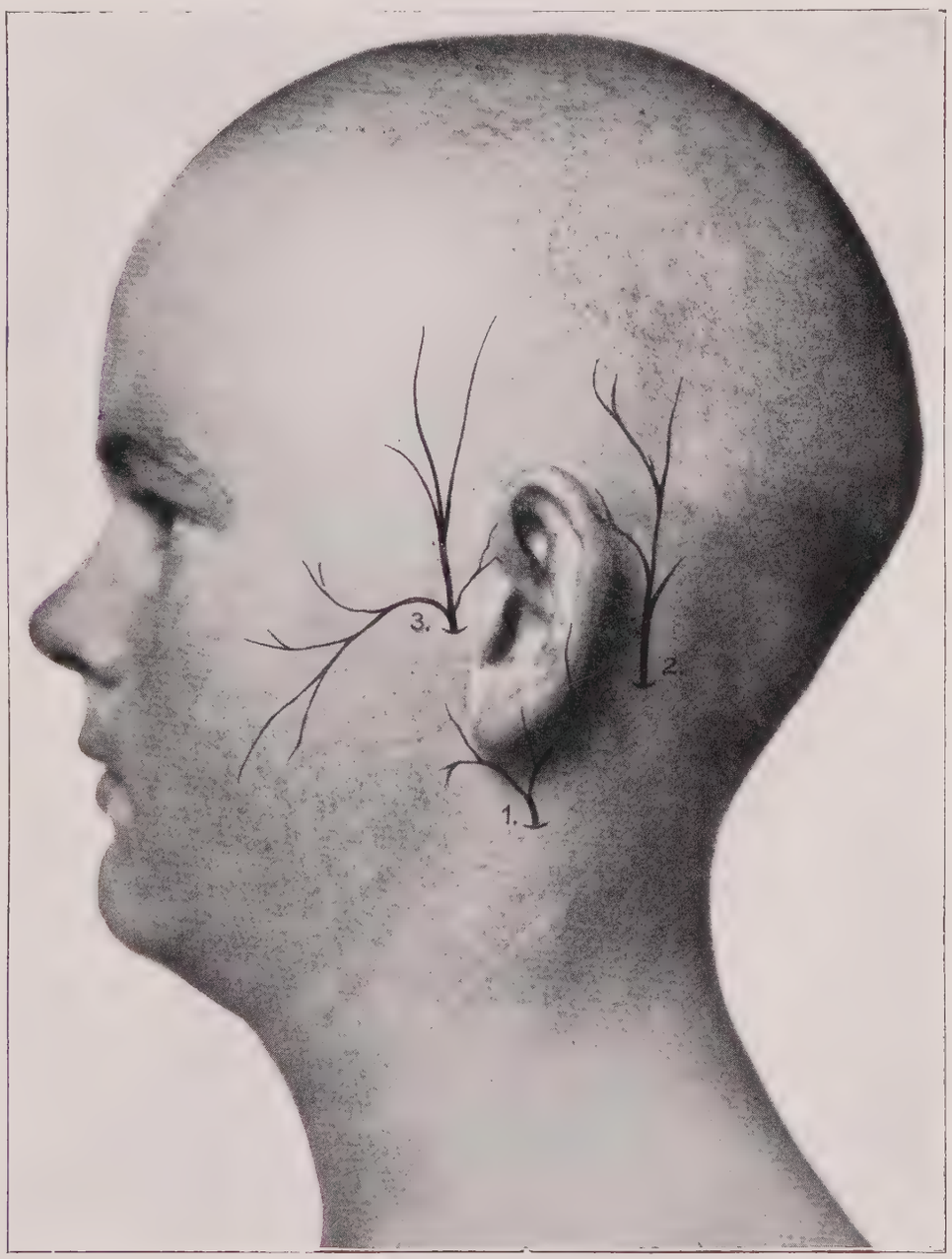

FIG. 44.—The nerves near the external ear. 1, N. auricularis magnus. 2, N. occipitalis minor. 3, N. auriculo-temporalis (trigeminus III).

onwards and upwards until the upper wall of the osseous meatus is reached, and the solution is then injected under moderate pressure. Neumann's object is to separate the upper wall of the meatus from its subjacent tissues, and so permit the solution to penetrate beneath the mucous layer of the tympanic membrane, and thus induce anæsthesia of the latter.

Van Eyken and Laval obtain anæsthesia of the cutaneous and bony structures of the meatus by injecting with a fine needle introduced from the point 2 in fig. 45, the injection being made in front of and behind the soft structures of the meatus. The needle passes

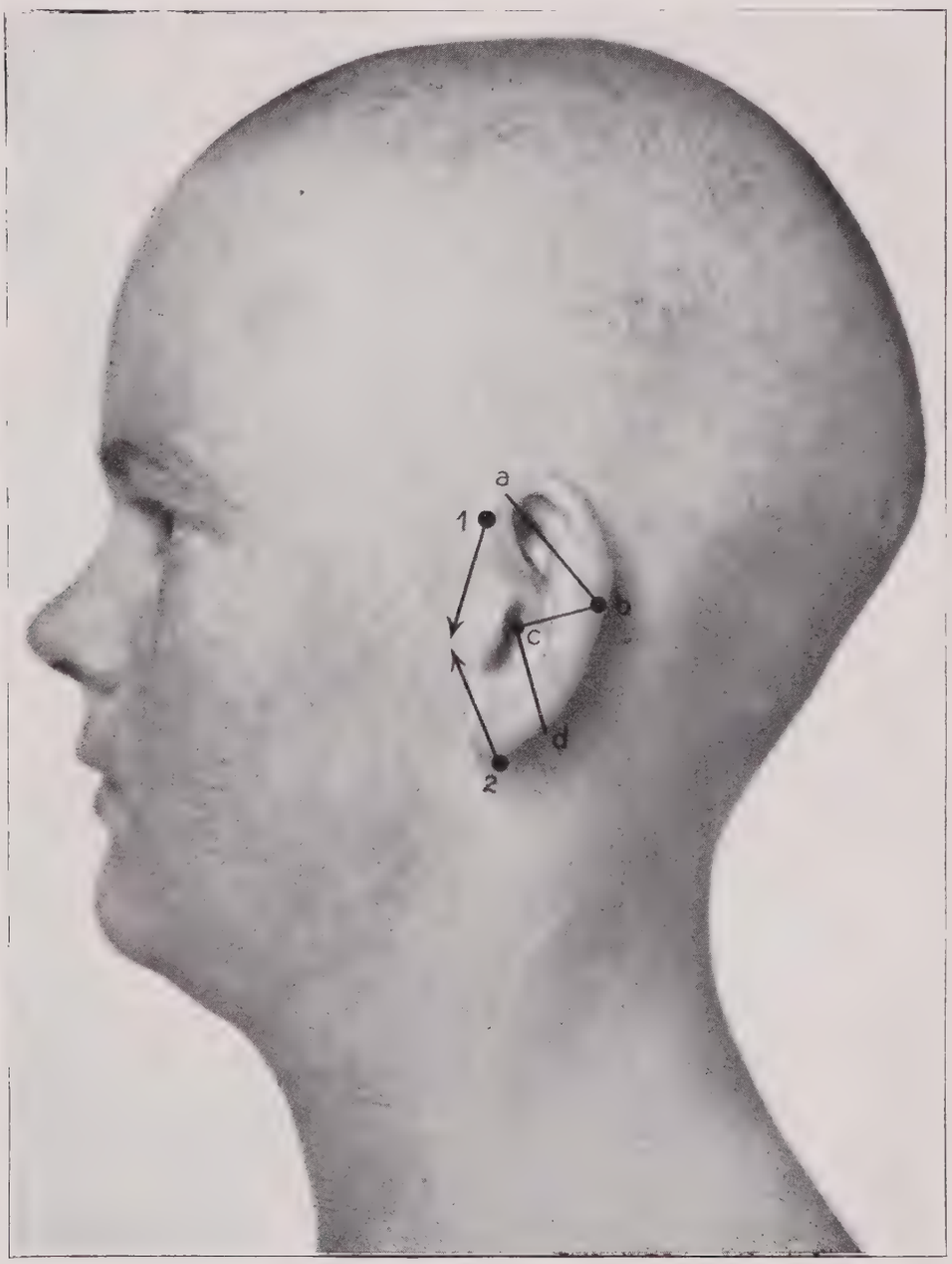

FIG. 45.—Injection of the outer ear, according to Braun.

along the anterior surface of the mastoid process towards the tympano-mastoidal fissure, and some of the solution is injected here, then also in a forward direction deeply at the posterior surface of the temporo-maxillary process. By this means the branches of the vagus and the auriculo-temporal nerves are anæsthetized.

Local Anæsthesia in Operations on the Neck.

(a) On the Front of the Neck.

The most important sensory nerve supplying mainly the anterior and lateral parts of the neck is the N. cutaneus colli (transverse superficial cervical) (see fig. 49). Besides, when dealing with the neck, we have to consider, as we shall presently see, the great auricular nerve and the supra-clavicular nerves.

The N. cutaneus colli is derived from the cervical plexus (either from the third or from the second and third cervical nerves), and reaches the surface about the middle of the sterno-cleido-mastoid muscle. At this point it curves round this muscle directing its course forwards under cover of the platysma, either medially or externally to the jugular vein. It divides into superior and inferior branches, which pass through the platysma, to reach the sterno-cleido-mastoid and anterior regions of the neck upwards as far as the border of the lower jaw. In operations on the front of the neck it is these nerves that have to be mainly considered.

In order to anæsthetize them it is best to follow Braun's instructions which are represented in fig. 46. The circumscribing figure is approximately that of a regular pentagon. The most important lines are *a b* and *c d*, because the main stem of the N. cutaneus colli can be interrupted at the external border of the sterno-cleido-mastoid muscle along them. The injection is therefore carried along the outer border. At the upper point the injection should be carried deeply to the transverse processes of the cervical vertebræ ; lower down it must be made through the sterno-cleido-mastoid. The connecting lines, for instance, *a e* and *b c* need only be injected subcutaneously or subfascially.

If the operation only involves one side of the neck a triangular area, for instance *a b c*, will be sufficient. If the floor of the mouth be involved the latter may be either infiltrated from the border of the jaw, or the two linguals may be interrupted. In producing this anæsthesia with which he performs the operation of removing the cervical lymphatic glands, for instance, for carcinoma of the lip or tongue, Braun uses 100 to 125 c.c. of 0·5 per cent. solution of novocain-suprarenin.

Although there are several possible variants of producing local anæsthesia of the neck, and these have been, and still are, much employed, this method of Braun's may be strongly recommended as the typical one.

Less extensive operations on the glands of the neck, or resection and incision of the sterno-cleido-mastoid for wry-neck, can be undertaken under simple local anæsthesia by infiltration around and under the field of operation.

The method of inducing local anæsthesia for tracheotomies is very simple. A Hackenbruch rhombus is circumscribed round the

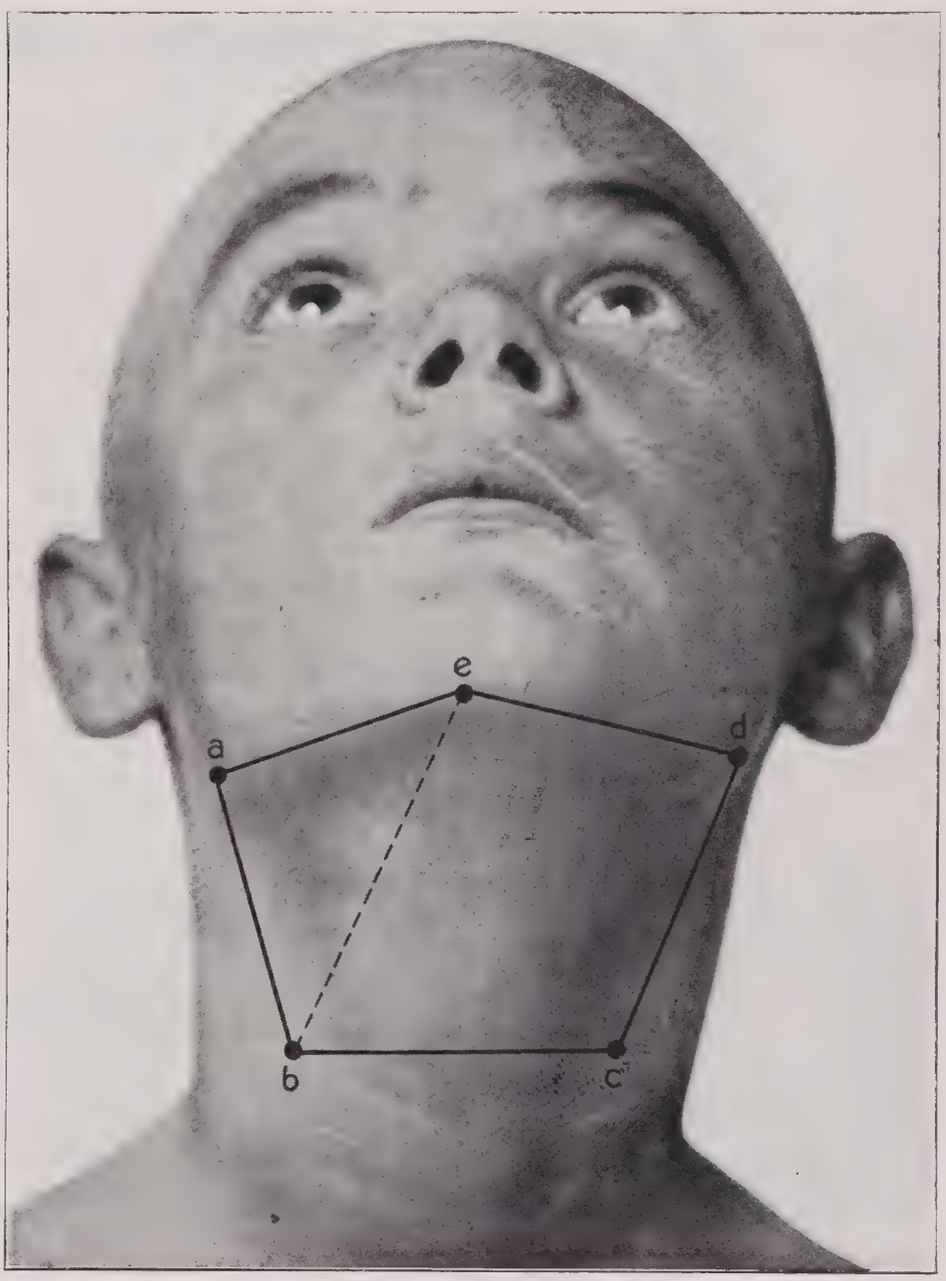

FIG. 46.—Conduction-anæsthesia of front of neck, according to Braun.

portion of the trachea which is included in the field of operation, and this is injected from four wheals subcutaneously and subfascially. Starting from the lateral point *a* the solution is injected laterally and under the trachea in the directions indicated by the arrows (fig. 47).

The circumscription of the field of operation by a rhombus is not absolutely essential. It is often sufficient merely to inject an infiltrat-

ing line along the course of the trachea; as a rule, as has been emphasized by Hohmeier, the field of operation is not in any way obscured by the infiltration of the line of incision.

For **extirpation of the larynx**, **Braun** recommends the following method: Starting from two points situated below the outer end of

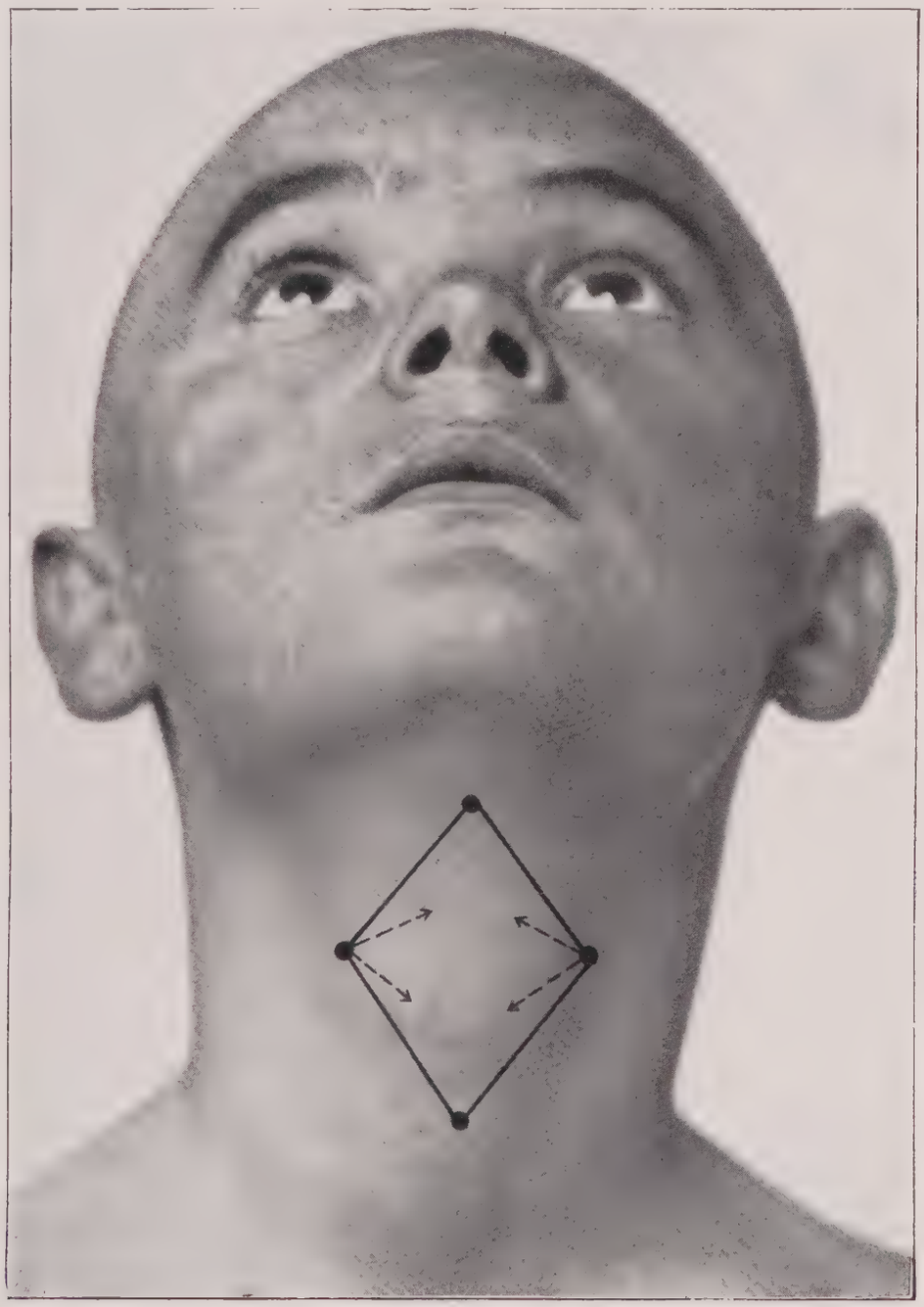

FIG. 47.—Anæsthesia for tracheotomy.

the great horn of the hyoid, at least 5 c.c. of 0·5 per cent. solution are injected on each side into the thyroid ligament, which must be thoroughly infiltrated. By this means the conduction of the superior laryngeal nerve is interrupted. From two other points situated somewhat lower at the inner border of the sterno-cleido-mastoid, deep injections are made towards the trachea, and, as far as possible,

towards its dorsal surface. Finally, one wheal is made at the lowest point over the trachea above the manubrium, and another under the chin ; from these points also deep injections are made. To complete the anæsthesia the six points forming a hexagon surrounding the larynx are united by subcutaneous injection.

Hohmeier anæsthetizes locally for extirpation of the larynx as follows : Starting from two points 2 cm. on each side of the thyroid notch the hyo-thyroid ligament is injected in order to anæsthetize the superior laryngeal nerves on both sides. Then using a slightly curved needle the posterior surfaces of the thyroid cartilage and trachea are injected from several points laterally to these two structures. Finally, the line of incision is infiltrated. Hohmeier uses about 150 c.c. of 0·5 per cent. novocain-suprarenin solution. The same method of anæsthetizing is required for laryngotomy.

The use of local anæsthesia in the case of **operations on the thyroid** is one of the oldest and the most generally recognized. In the first place the risks of general anæsthesia, which are particularly important in such operations on account of stenoses or post-operative pneumonias, are avoided, and in the second place local anæsthesia facilitates the finding of the recurrent laryngeal nerve and so diminishes the risk of its being injured. Socin was among the first to draw attention to the advantages of local anæsthesia in such cases, and it has been recommended by many, among them being von Bier and Madelung. In the Heidelberg surgical clinic also it has been a rare occurrence for many years for a general anæsthetic to be administered for goitre operations. Now and then in the case of children, or very timid adult patients suffering from goitre, and perhaps in one or other case of exophthalmic goitre a general anæsthetic may have been administered.

The procedure for inducing local anæsthesia in these cases may be very simple. The most common method adopted at the **Heidelberg** clinic, usually with excellent results, is the following: Starting from one or two points above the highest part of the thyroid tumour, the line of incision is infiltrated along a curved line on both sides as far as the sterno-cleido-mastoids, or occasionally even further. The 0·5 to 1 per cent. solution of novocain-suprarenin is injected copiously into the subcutaneous tissues and muscles. From the line of incision also these two layers are injected upwards and downwards, an anæsthetic zone of at least 3 cm. width being formed.

If the surgeon has accustomed himself to it, he will not be disturbed in any way by the resulting imbibition. Such an injection into the line of incision alone will not however suffice to render anæsthesia complete. The freeing of the tumour and lifting it out of the wound causes considerable pain ; the latter can be avoided almost entirely if deep injection towards the sides of the larynx and trachea, from the

lower and upper poles of the tumour be superadded to the infiltration of the line of incision.

Braun only became an adherent of local anæsthesia in goitre operations after he had elaborated a method of his own. His method is as follows (fig. 48): Starting from two points *a* and *b*, situated on

FIG. 48.—Anæsthesia for goitre.

the sterno-cleido-mastoid, extensive infiltration of all the layers of tissue covering the tumour (hyoid, sternum, laryngeal muscles, sterno-cleido-mastoid and subcutaneous cellular tissue) is carried out. From the other points the surface of the tumour is injected as well as in the direction of the next point.

If both lobes of the gland be affected the procedure should be carried out on both sides, as has also been described by Hacken-bruch.

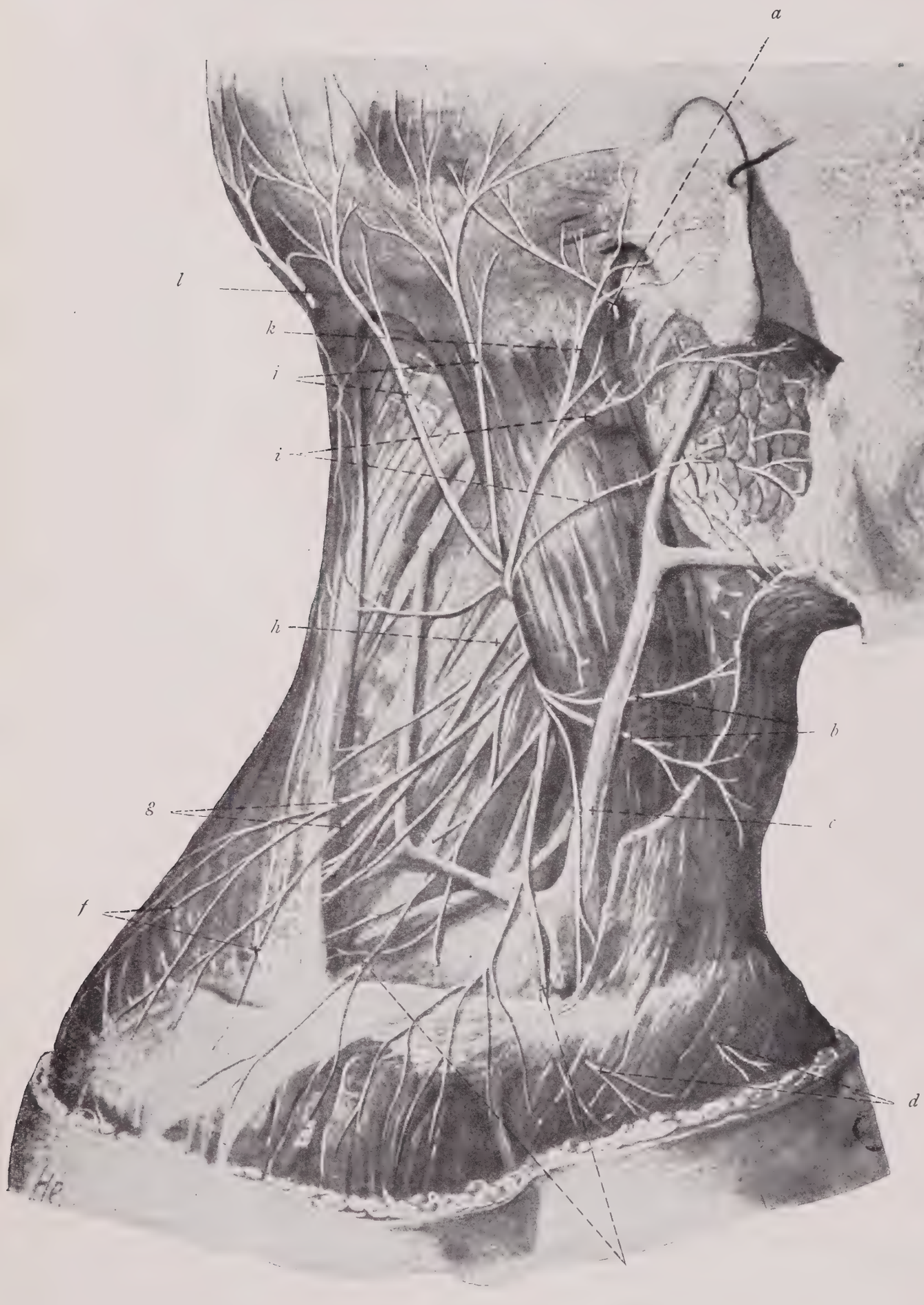

FIG. 49.—(After Spalteholz.) *a*, N. auricularis post. *b*, N. cutaneus colli. *c*, V. jugularis ext. *d*, Nn. supraclaviculares ant. *e*, Nn. supraclaviculares medii. *f*, Nn. supraclaviculares post. *g*, Nn. supraclaviculares. *h*, N. accessorius. *i*, auricularis magnus (ramus ant.). *j*, N. occipitalis minor. *k*, N. auricularis magnus (ramus post.). *l*, N. occipitalis minor.

(b) Operations on the Side of the Neck.

In operating on the lateral part of the neck the great auricular and the supraclavicular nerves have to be considered as well as the N. cutaneus colli (transverse cervical) above mentioned (fig. 49).

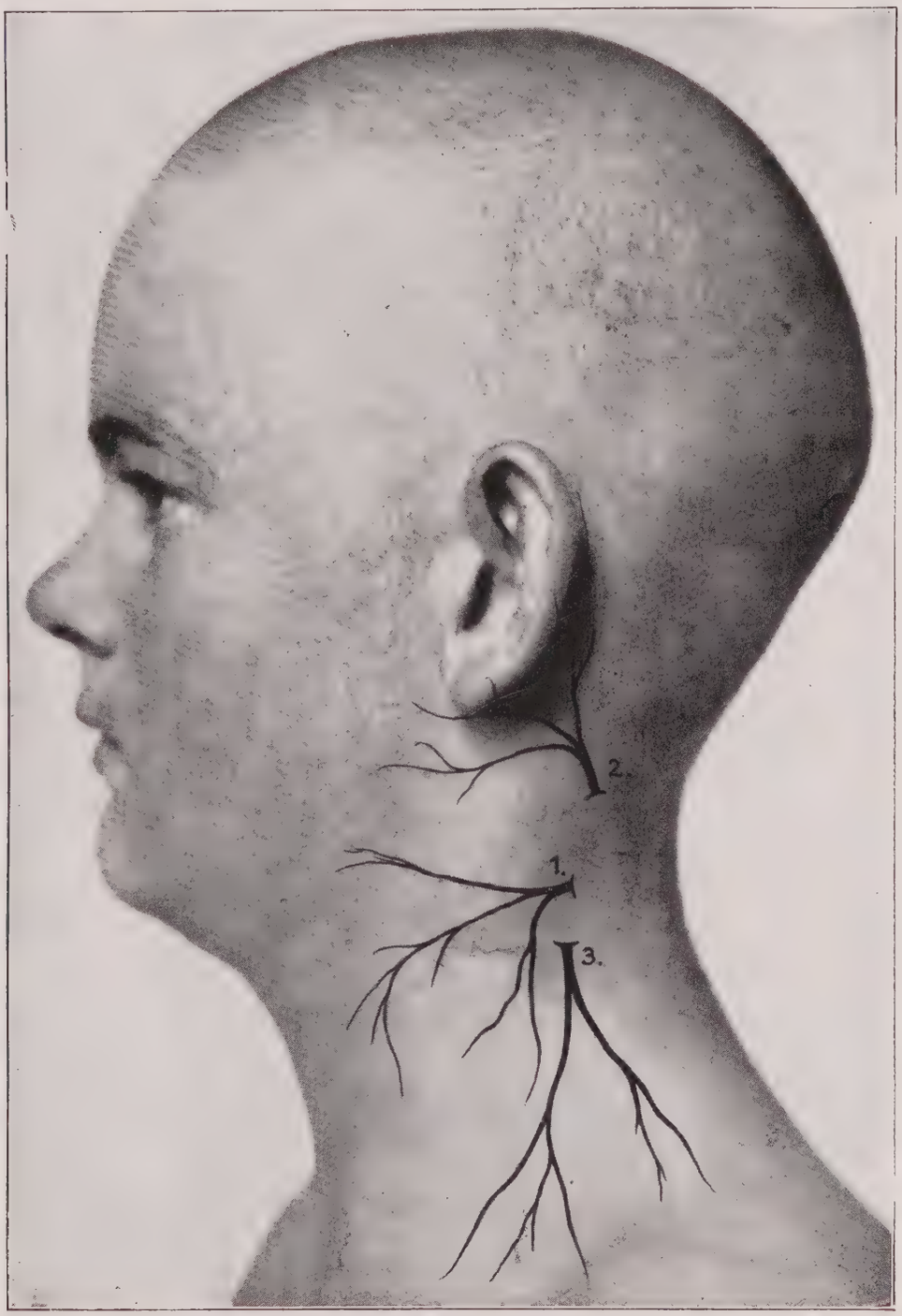

FIG. 50.—The nerves of the side of the neck. 1, N. cutaneus colli. 2, N. auricularis magnus. 3, Nn. supraclaviculares.

If these three main nerves, cutaneus colli, auricularis and the supraclaviculares (fig. 50) are reached by the anæsthetizing solution from a strip of injection along the external border of the sterno-cleido-mastoid subcutaneously and under the platysma, as indicated by the

line *a b* in fig. 51, a large insensitive area is formed, as shown by the hatching in fig. 51. This method of anæsthetization was suggested by Braun.

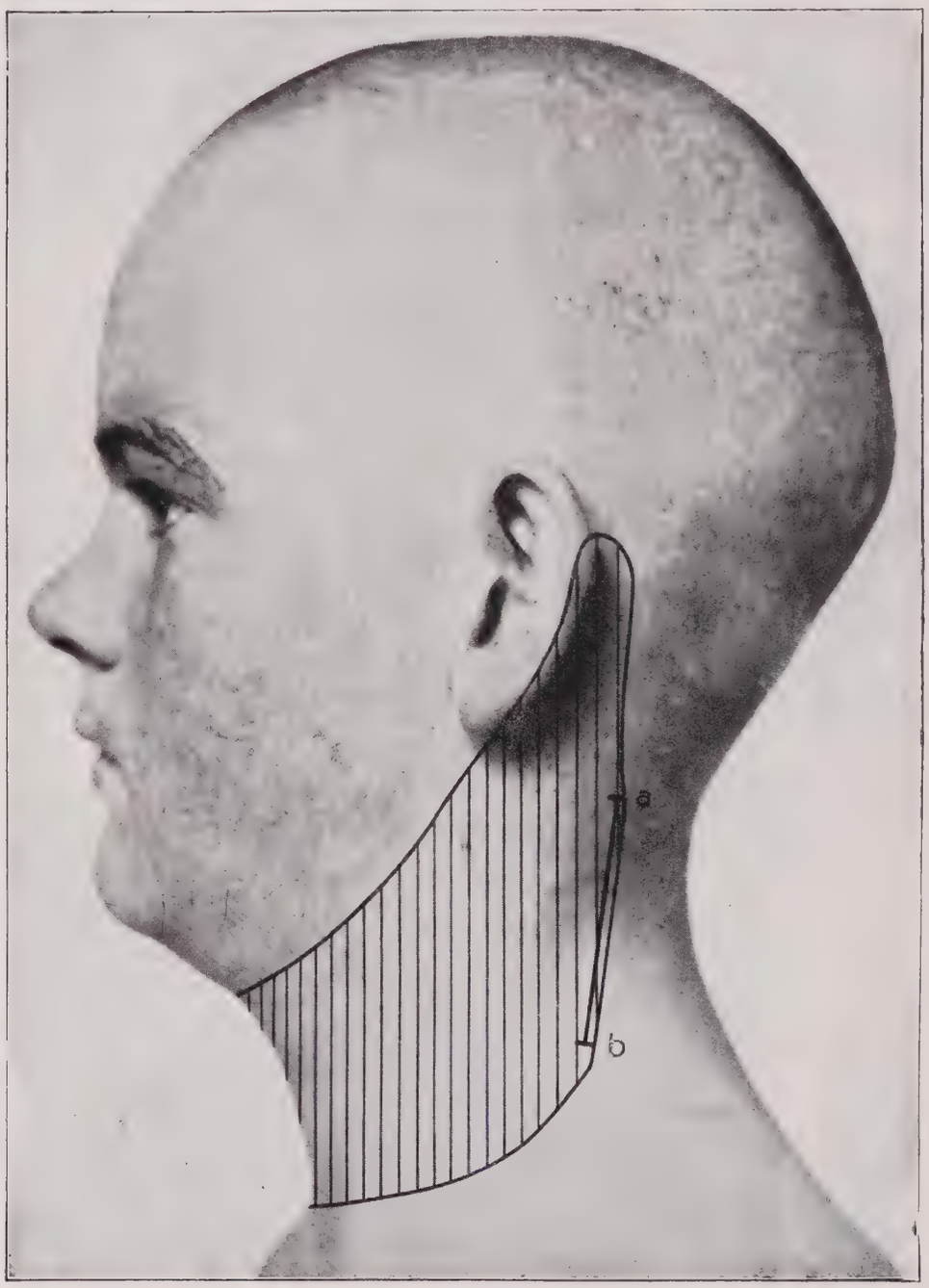

FIG. 51.—Conduction-anæsthesia of side of neck, according to Braun.

By it superficially situated tumours and glands can be removed; for glands which are more deeply situated this form of anæsthesia does not suffice; injection under the whole field of operation as far as the great vessels must be superadded.

Local Anæsthesia in Operations of the Thorax and Breast.

Practically the entire field of thorax and breast surgery has been conquered for local anæsthesia within the last few years. Operations which used to be dreaded on account of the length of time they took to perform, and hence also on account of the risks entailed by using general anæsthesia, such as extensive thoracoplastic operations, are now performed in the most simple manner under local anæsthesia. As in other cases, so here the bloodlessness contributes greatly to the success of the operation. Extensive loss of blood, such as occurred formerly in thoracoplastic operations, is now entirely avoided.

FIG. 52.—Circum-injection of clavicle.

In operations on the breast also local anæsthesia has yielded great advantages. The dangers of amputation of the breast under general anæsthesia in weakly, cardiac and pulmonary patients have been removed by the introduction of local anæsthesia in this operation.

(a) Operations on the Clavicle.

For operations on the clavicle simple infiltration-anæsthesia by circum-injecting the area is quite sufficient (fig. 52).

Starting from two points, one above, the other below the clavicle, subcutaneous and deep injections are made in the directions indicated by the arrows, whereby a rhombus is described, in the centre of which is the clavicle. From the same points injections are then made in

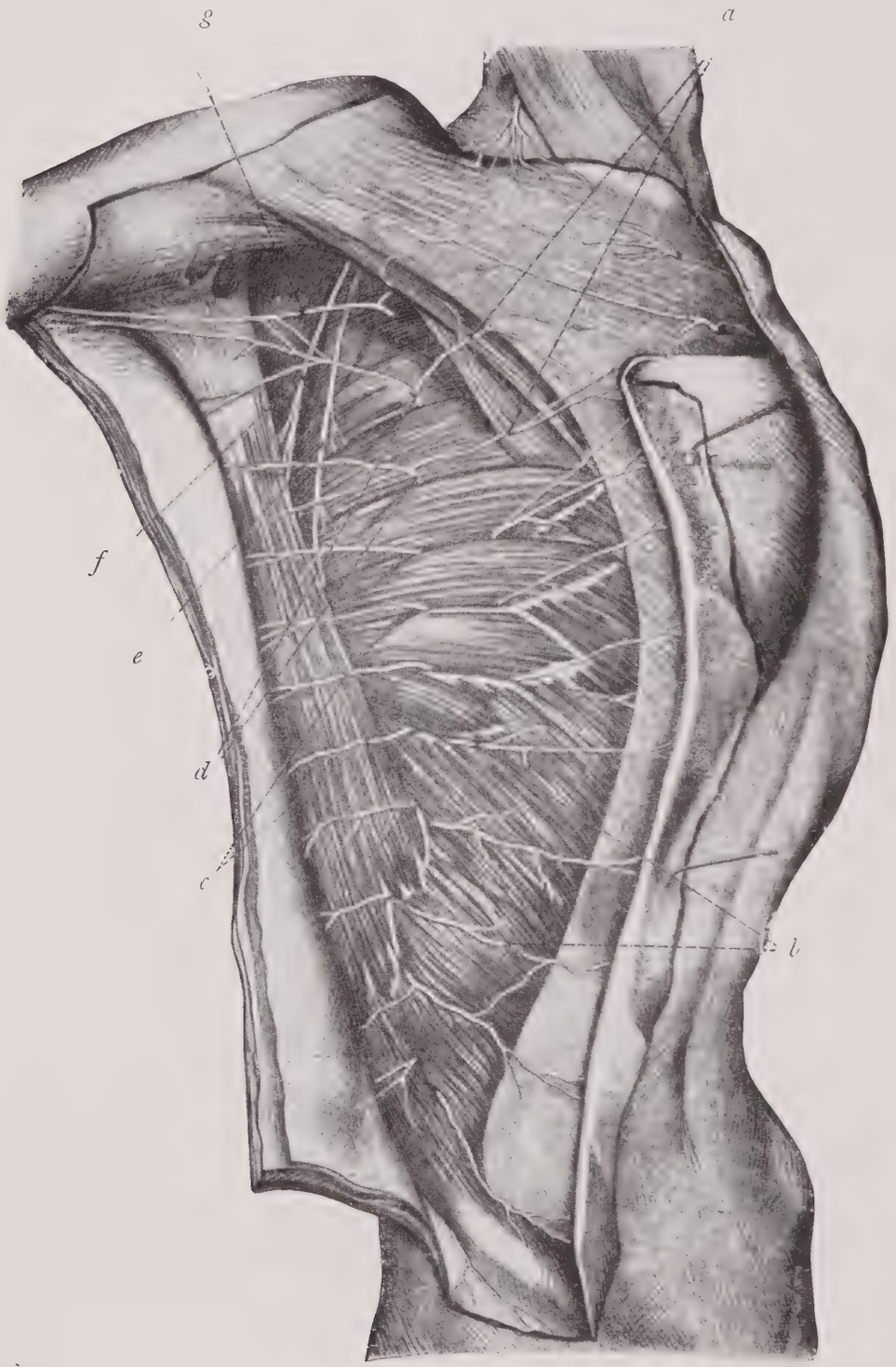

FIG. 53.—(After Toldt.) *a*, Rami anteriores of Rami cutanei laterales. *b*, Rami anter. of Rami cutanei laterales (abdominales). *c*, Rami posteriores of Rami cutanei laterales (abdominales). *d*, Rami cutanei laterales (pectorales). *e*, N. thoracalis longus. *f*, N. subscapularis. *g*, N. intercosto brachialis.

various directions well beyond the field of operation towards the periosteum and under the clavicle (these are indicated by only two dotted arrows on each side in the illustration). About 30 c.c. of 0·5 to 1 per cent. novocain-suprarenin solution will be necessary.

(b) Resection of the Ribs. Thoracoplastic Operations.

Of the thorax operations performed under local anæsthesia, that of resection of the ribs is the most frequent. It is one of the most favourable, for in the first place here again the risks of general anæsthesia for patients who suffer from pulmonary or pleural diseases are avoided, and on the other hand, this operation, which so often

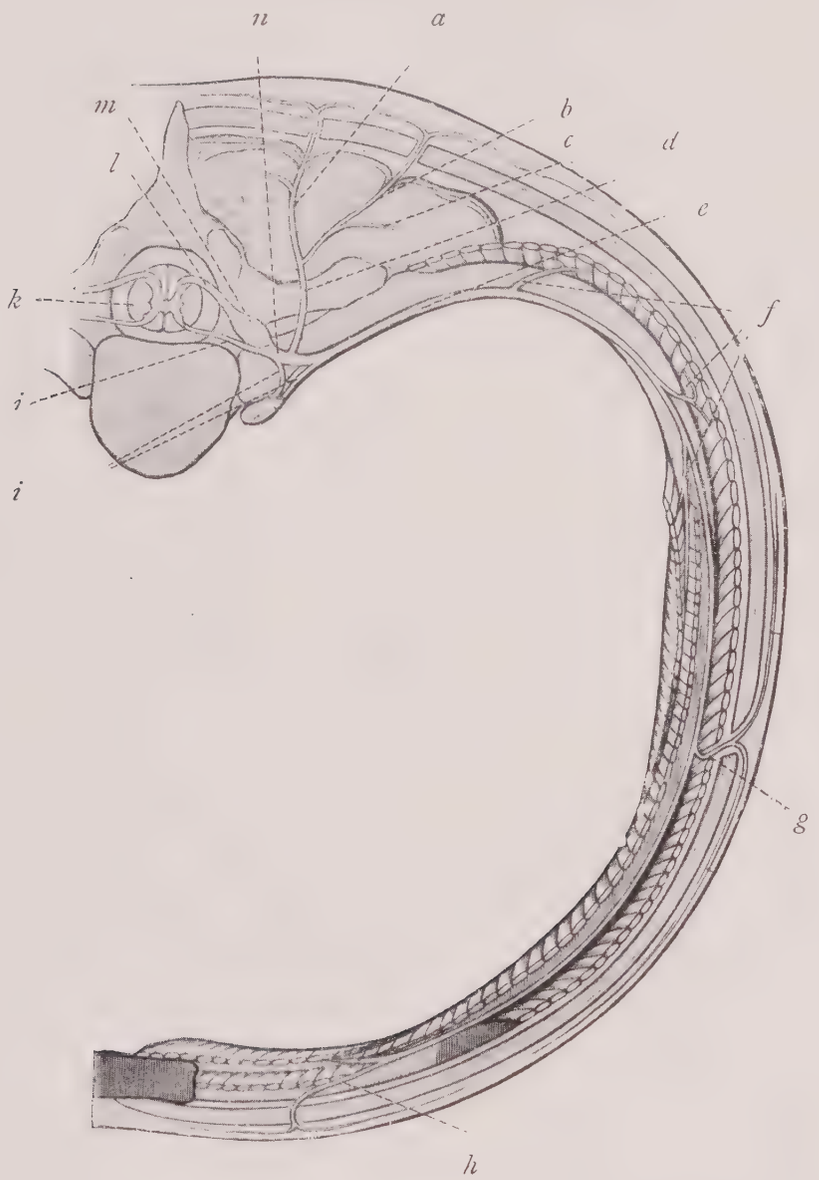

FIG. 54.—(After Toldt.) Diagram of the branches of the Intercostal Nerves. *a*, Ramus cutaneus dorsalis (medialis). *b*, Ramus cutaneus dorsalis (lat.). *c*, Ramus muscularis. *d*, Ramus post. of the N. thoracalis. *e*, N. intercostalis. *f*, Rami musculares. *g*, Ramus cutaneus lateralis. *h*, Ramus cutaneus anterior. *i*, Ramus communicans. *j*, Radix anterior. *k*, Medulla spinalis. *l*, Radix posterior. *m*, Ganglion spinale. *n*, N. spinalis (thoracalis).

leads to the saving of the patient's life, is rendered possible by a simple and certain method of anæsthesia. In this case the anæsthesia is definitely a conduction-anæsthesia.

For the carrying out of the method a thorough knowledge of the course of the intercostal nerves is indispensable. The dorsal nerves divide into a posterior and an anterior branch, the former divides

again into a lateral and medial twig and supplies the muscles and skin of the back.

The more important branch of the dorsal nerve is the anterior or intercostal nerve. This passes for some distance along the inner side of the thoracic wall, being covered by the endothoracic fascia and pleura. The first two intercostal nerves lie on the inner surface of the ribs, the others take their course along the intercostal spaces. The main branch of the intercostal always lies next to the upper rib of its space, sending off a branch outwards at the side of the thorax, the lateral cutaneous branch (figs. 53 and 54). The main trunk of each of the five upper nerves continues along the intercostal spaces until, near the sternum, it gives off a cutaneous branch anteriorly, the anterior cutaneous branch (fig. 54). From below the level of the fourth intercostal nerve, each intercostal also gives off a twig to the rectus abdominis muscle. From below the level of the sixth or seventh the main trunk of each intercostal nerve emerges over the costal cartilage between the transversus and the obliquus internus muscles, sends off a twig to these and then continues obliquely downwards over the abdominal wall.

The lateral cutaneous branches of the intercostal nerves (fig. 54) leave the upper main nerves earlier than they do the lower, and run a like course for some distance; they then emerge between the serrations of the serratus anticus major, the lower at the costal serrations of the latissimus dorsi and between these and the lower costal serrations of the obliquus abdominis externus. They then divide into one anterior and one posterior twig each. The latter is the stronger in the case of the upper intercostals and bending round the lateral border of the latissimus dorsi is distributed to the skin of the back. The anterior twig is the stronger in the lower intercostals.

The anterior cutaneous branches of the intercostal nerves (fig. 54) in the case of the upper intercostals emerge at the side of the sternum, pierce the pectoralis major muscle, and are distributed as anterior pectoral cutaneous nerves to the skin of the chest.

We can thus differentiate three points of emergence for the cutaneous branches of each intercostal nerve. The first at the spinous processes, the second at the level of the axillary line, and the third about 2 cm. external to the border of the sternum.

From the point of view of inducing conduction-anæsthesia it is a great advantage that every intercostal nerve at the commencement of its course, and before dividing into an upper and lower branch, consists of a main stem which runs along the centre of the intercostal space. The division only takes place near the angle of the rib (fig. 55). After division the thicker upper branch is closely applied to the lower border of the rib, partly in a groove; the thinner of the two nerves runs along the upper border of the lower rib, occasionally along its posterior surface (fig. 55).

Taking this anatomical fact into account, it is evident that one may strike the intercostal nerve either as a main trunk at the angle of the rib in the centre of the intercostal space, or after its division

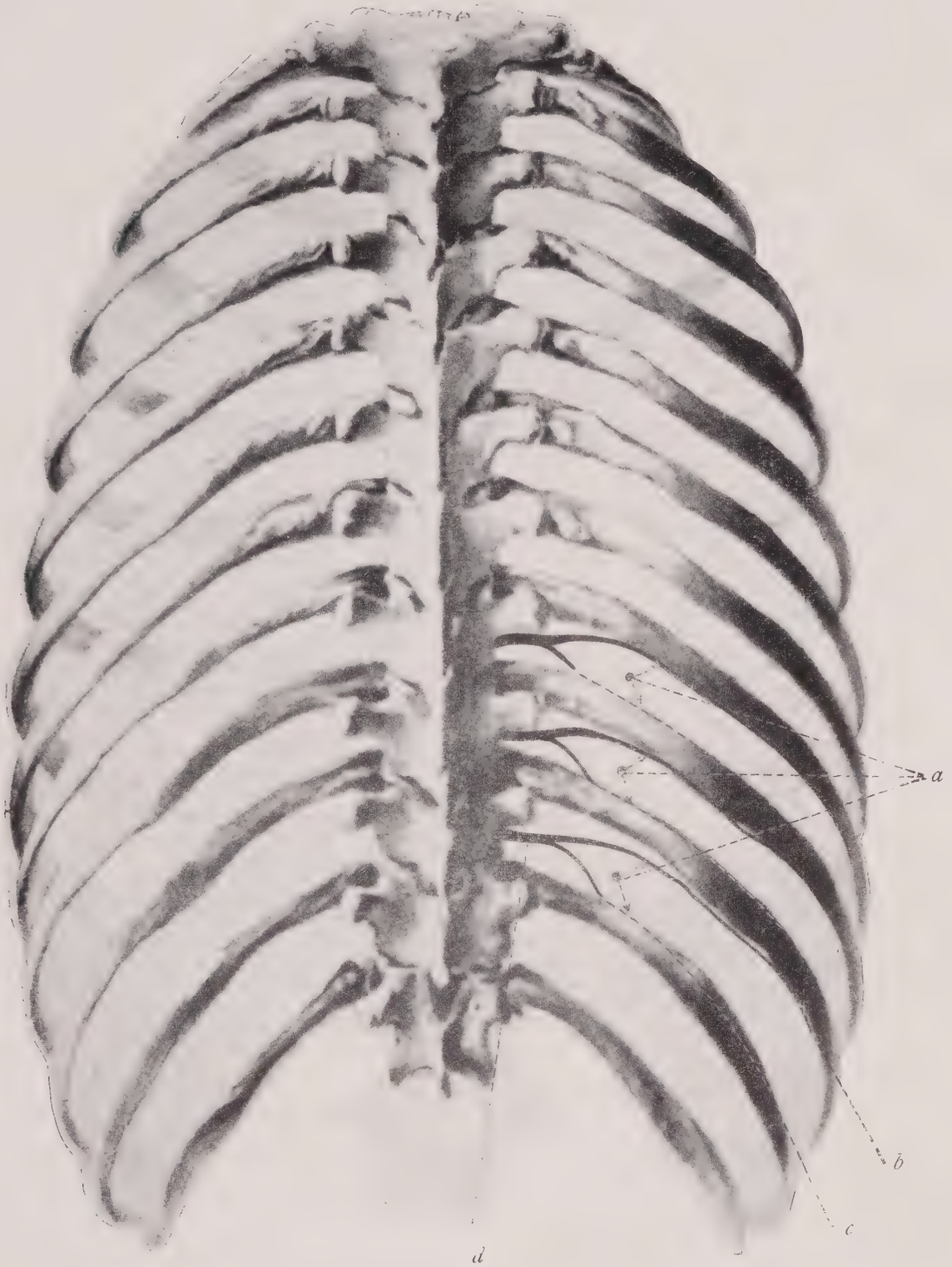

FIG. 55.—Course of the Intercostal Nerves and the possible modes of injecting them. *a*, Injection into the branches of the intercostal nerves. *b*, Upper, and *c*, lower branches of intercostal nerve. *d*, Injection into the main trunk of intercostal nerve.

into an upper and a lower branch by two injections, one each directed towards the borders of the ribs (fig. 55).

In the case of resection of the ribs and thoracoplastic operations in the neighbourhood of the vertebral column, the first alternative of

striking the main trunk of the nerve in the middle of the intercostal space would probably be the simpler method of inducing conduction-anæsthesia. The soft parts over the ribs to be resected would then still remain to be infiltrated adequately both distally and proximally. The technique may be varied according to the kind of thoracoplastic operation to be performed, and according to the extent of rib to be resected, either the trunks of the intercostal nerves being injected in the middle of the intercostal spaces at the angles of the ribs, or the

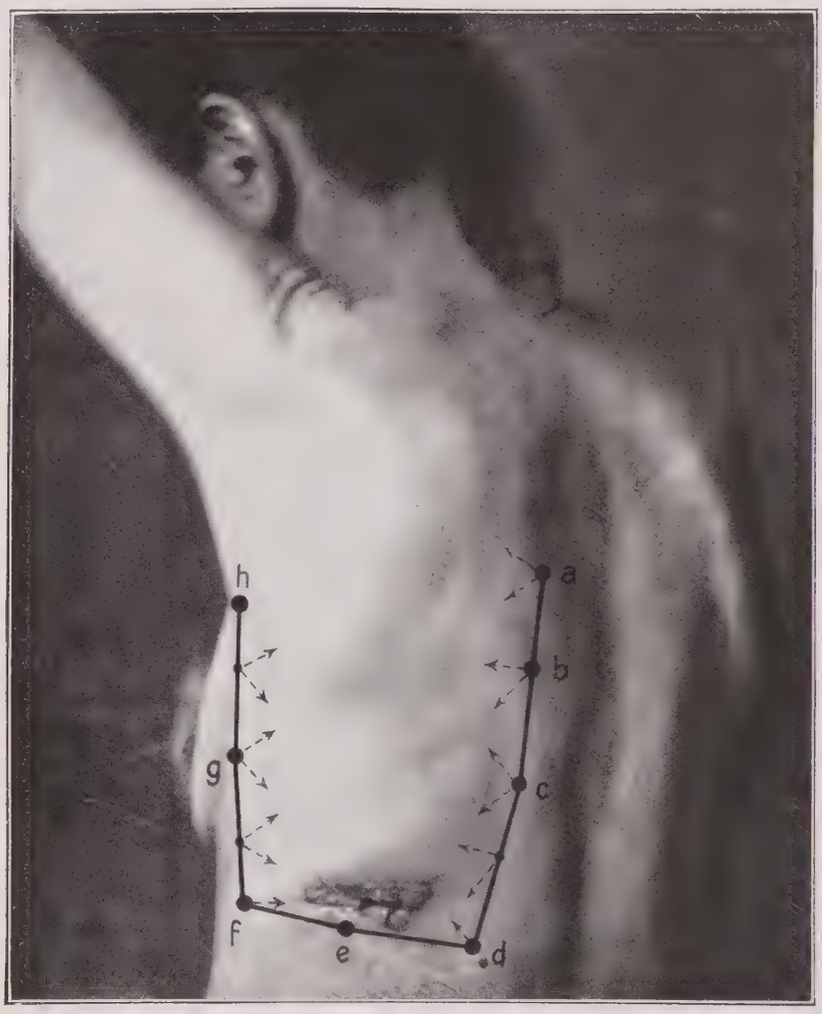

FIG. 56.—Injection for thoracoplastic operation. (Schede.)

individual branches being anæsthetized at the borders of the ribs. According to the experience of the author the latter would appear to be always the more certain method. When the intercostal spaces are narrow, or where the ribs are displaced close to or overlapping one another injecting 5 to 10 c.c. of 0·5 per cent. novocain-suprarenin solution into the middle of the intercostal space will suffice.

We use our ordinary straight thin needles for intercostal injections; it is not necessary to use curved needles as suggested by Hohmeier. The strength of the novocain-suprarenin solution employed is usually 0·5 to 1 per cent.; if larger quantities have to be injected, the weaker

solution should be preferred. Eight to ten cubic centimetres of the 0·5 per cent. solutions are sufficient for each intercostal space.

The **author has described a method** of inducing local anæsthesia in more extensive **thoracoplastic operations**. It is as follows :—

Having obtained an idea of the size of the cavity by probing, &c., the entire field of operation is circumscribed by subcutaneous injection (fig. 56). The line of injection extends from *a* to *h* and includes the fistulous opening. From several points on this line the injections intended to strike the intercostal nerves are made. If the operation be near the angles of the ribs single medial injections in the intercostal spaces will suffice, as the nerve is there encountered as a single trunk. If the resection be carried out on an area further removed from the vertebral column it is best to inject the two branches from the middle of the intercostal space, directing the needle first to the upper border of the lower, then to the lower border of the upper rib, in each intercostal space. These deep injections are represented in fig. 56 by arrows. The arrows at *f*, *g*, and *h* indicate deep injection into the subcutaneous and muscular tissues ; a second interruption of the intercostal nerves at these points is superfluous. Ten cubic centimetres of 0·5 or 1 per cent. solution of novocain-suprarenin are sufficient for each intercostal space.

It must not be forgotten that in every case one rib above and one below the absolutely necessary spaces should be anæsthetized on account of the nerve anastomoses with neighbouring intercostals. When the ribs overlap, as in old empyemas on which resections have already been performed, it may become necessary to anæsthetize the more deeply situated rib after removal of the covering one.

Garrè and Schuhmacher have described similar procedures for anæsthetizing in cases of thoracoplasty.

The anæsthetizing in cases of **Wilms' thoracoplastic operation** in pulmonary tuberculosis, in which only smaller pieces of rib and costal cartilage are removed, though even these may attain a length of several centimetres, is similar but rather simpler in performance.

The method is as follows : The subcutaneous tissues are first anæsthetized in a manner analogous to that above described from several points along a line drawn down the border of the sternum (fig. 57, *a*, *b*, and *c*). From the same points of puncture and some additional ones on the line of injection the needle is inserted into the middle of the intercostal spaces, and pushed laterally towards the borders of the ribs (dotted arrows), the intercostal nerves being put out of action by the injection of a few cubic centimetres of 0·5 to 1 per cent. solution of novocain-suprarenin. It is quite easy to reach the first rib from the point *a* ; the needle is introduced until it strikes the border of the rib and is then conducted along its under surface,

keeping in touch with the bone. The intercostal nerve is readily met in this manner. By these injections the intercostal nerves are interrupted, and there now remains the anæsthetization of the subcutaneous tissues towards the sternum for a distance corresponding to the extent of cartilage to be removed; this is done by again

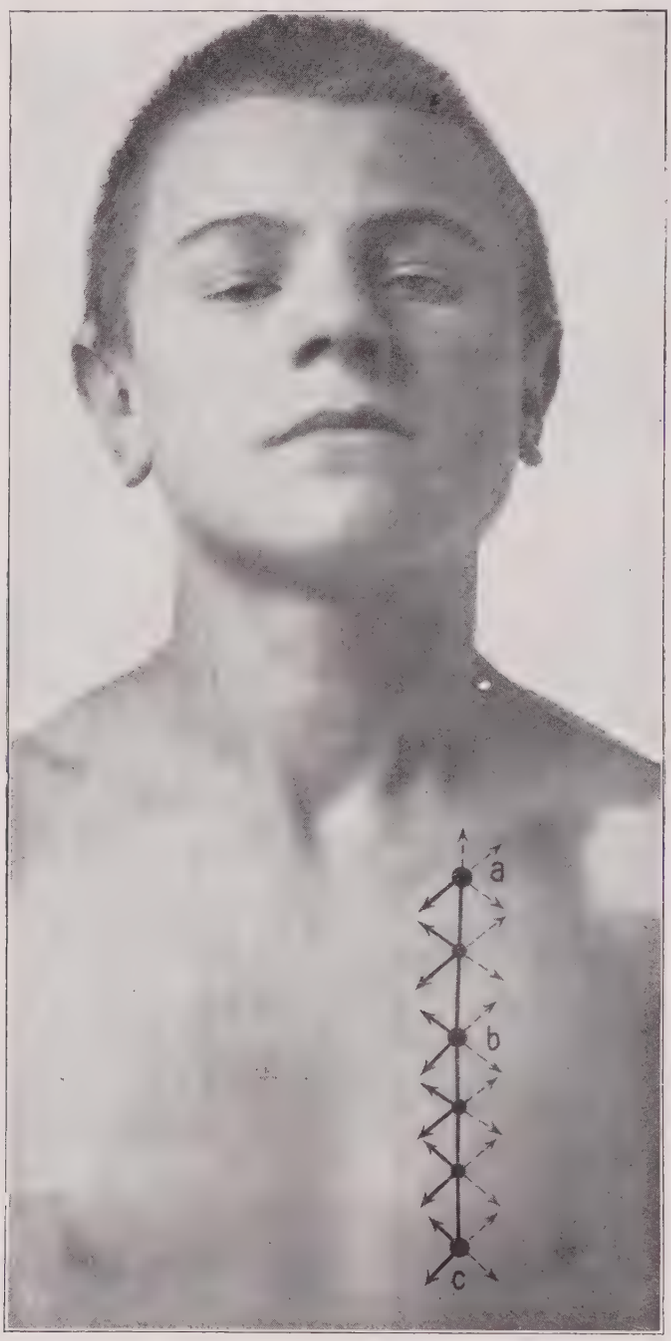

FIG. 57.—Injection for thoracoplastic operation, according to Wilms. (Anterior view.)

introducing the needle at the same points and injecting a few cubic centimetres of the solution into the subcutaneous tissue in the directions indicated by the arrows.

For the Wilms operation in the dorsal region near the vertebral column, the procedure is similar, only in this case the intercostal anæsthesia is performed on the medial side of the line of injection towards the vertebral column (fig. 58).

In this operation if it be near the angles of the ribs, the intercostal nerve may be anæsthetized by single injections into the main trunks as described above. If the injection has to be made more laterally, double injection of the branches should be performed, as indicated by the arrows in the illustration (fig. 58). Here also, as in the case of the anterior operation, the actual injection of the intercostal nerves should be preceded by subcutaneous infiltration along a line (*a*, *b*, *c*) from one or more points. According to the size of the pieces of ribs to

FIG. 58.—Injection for thoracoplastic operation, according to Wilms. (Posterior view.)

be removed, the subcutaneous tissues of the distal side should also be infiltrated from the same points by means of a few cubic centimetres of solution; 50 to 70 c.c. of 0·5 per cent. solution of novocain-suprarenin should suffice for the entire thoracoplasty.

Braun anæsthetizes for **chondrectomies** on account of emphysema of the lungs in a similar manner.

When only one rib is to be resected the anæsthetizing procedure is very simple. There are several methods by which complete anæsthesia may be obtained in these cases.

That usually now adopted by Braun is as follows: Four points of puncture are indicated in the centre of the intercostal spaces next to the rib that is to be operated on. From each of these the needle is inserted vertically through the skin into the intercostal space and 5 c.c. of 1 per cent. novocain-suprarenin solution are injected between and under the intercostal muscles near the lower border of the upper ribs. Finally the whole field of operation is circumscribed subcutaneously by infiltration.

As Braun emphasizes, it is possible to resect ribs under local anæsthesia in cases of empyema even in infants in the first year of life.

(c) Operations on the Breast.

Where it is a question of removing small tumours of the breast such as fibromata, adenomata, &c., the induction of local anæsthesia is very simple. The tumour is circumscribed by injections round and under it, using 0·5 per cent. novocain-suprarenin solution.

Many years ago Braun used to remove the whole breast in thin subjects by circumscribing the tumour. But he considered local anæsthesia unsuitable for amputations of the breast for malignant tumours.

Two years ago Hirschel described a method of local anæsthesia for such operations. By this method it is possible to perform typical amputation of the breast including the removal of the pectoral muscles and clearing out of the axilla under complete local anæsthesia. It is true that in obese patients the procedure is rendered far more difficult, but even here it may be carried out satisfactorily by using large quantities of anæsthetizing fluid.

The sensory nerves that have to be taken into account in amputation of the breast are: the intercostal nerves, the anterior thoracic nerve, the intercosto-brachialis (intercosto-humeral) nerve supplying the axilla, and the brachial plexus. The interruption of the conduction of the intercostal nerves is readily performed by the method above described. The anterior thoracic and the intercosto-brachial nerves are anæsthetized simultaneously with the brachial plexus (*cf.* also fig. 53).

The **method described by Hirschel** is as follows (fig. 59): From the point *a* in the axilla the whole field of operation is circumscribed by subcutaneous injection through *b*, *c*, &c., up to *k*; 0·5 per cent. solution of novocain-suprarenin will be sufficiently strong for this purpose. Then the intercostal nerves are anæsthetized from the points *b*, *c*, *d*, &c., along the lateral line of circumscription (only three such injections have been indicated on the figure; as a matter of fact some of the ribs are more important than others). The injection of the intercostal

nerves is carried out as above described. The needle is inserted into the middle of the intercostal space and then turned, keeping in touch with the bone first towards the border of the upper then towards that of the lower rib. For this purpose approximately 8 to 10 c.c. of 1 per cent. novocain-suprarenin solution will be required. On the medial side from points *f* to *k* the nerves need not be again injected; they are the points from which deep injections are carried into the mammary tissues and into the pectoral muscles.

The final and the most important part of the procedure is the anæsthetizing of the brachial plexus with which the operator comes in contact when clearing out the axilla. This is done by inserting

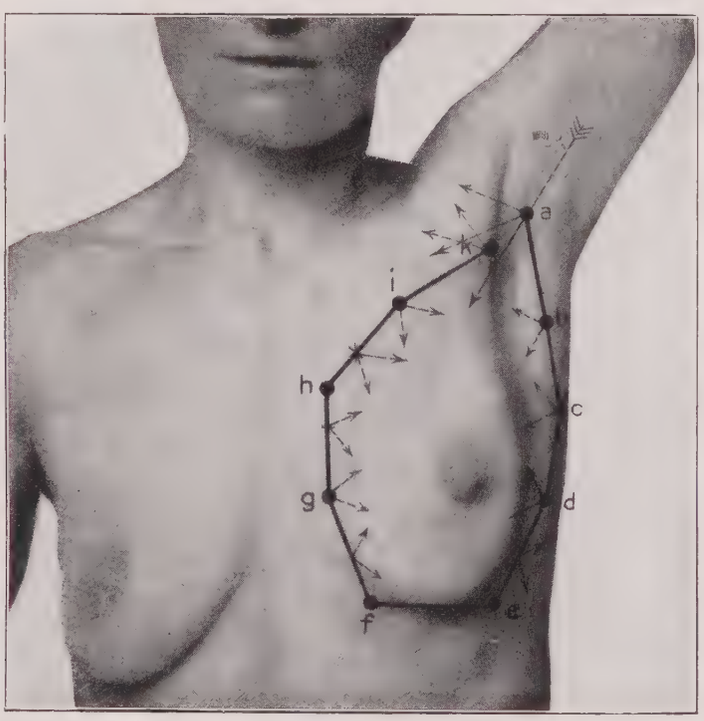

FIG. 59.—Injection for operation for carcinoma mammæ.

the needle at the point *a* and pushing it onwards under the pectoralis major towards the first rib along the course of the great vessels which should be found by palpation; whilst doing this the solution should be injected all the time. The direction of the injections is indicated by arrows starting from *a*. In addition to that of the brachial plexus, the conduction of the intercosto-brachialis and anterior thoracic nerves are interrupted by these injections. For anæsthetizing the brachial plexus, about 30 to 40 c.c. of 1 per cent. solution of novocain-suprarenin will be required. Injury to the great vessels of the arm have not so far occurred. The anæsthesia induced is always most satisfactory, even that of the brachial plexus, which is constantly being met with, whilst removing the fat and glands from the axilla.

Quite recently Hohmeier has described a method for anæsthetizing for amputation of the breast, which is similar to that of

the author as regards the essential point, the anæsthetizing of the brachial plexus. His method differs from that above described in that he does not induce induction-anæsthesia of the intercostal nerves for the tissues of the mamma and the muscles, but starting from three points below and two above the mammary gland infiltrates the field, that is to say, injects round and under the tumour. Finally he anæsthetizes the border of the latissimus dorsal muscle. Hohmeier uses 300 c.c. of 0·5 per cent. novocain-suprarenin solution for the entire anæsthesia.

Local Anæsthesia in Abdominal Operations.

In this field of operative surgery the advances made by local anæsthesia have not kept pace with those made in other parts of the body. It is certainly true that it may be used satisfactorily in many abdominal operations, but in the case of extensive operations which have to be performed completely painlessly, it is at present not applicable.

Isolated resections of the bowel and stomach were undertaken years ago by various surgeons under local anæsthesia. It is commonly employed for gastrostomies and colostomies, and in some cholecystostomies. The applicability of local anæsthesia in these cases always depends on the physical and psychical condition of the patients.

To ensure better results, the usual practice is to administer morphia before the operation, as is the case, generally speaking, before all more extensive local anæsthesias. But in the case of abdominal operations morphia administered previous to the operation seems to be particularly indicated on account of its sedative effect.

Colmers and Stenglein recommend pantopon-scopolamine very warmly, and, indeed, in full doses. Colmers administers 0·02 grm. of pantopon and one tablet of 0·0003 scopolamine one and a-half to one and three-quarter hours before the operation, and calms the patient by a dose of 0·5 to 1 grm. of veronal administered the evening before.

A kind of general narcosis is induced by these very full doses of narcotics, so that extensive local anæsthesia may no longer be necessary for the performance of the operation.

In the case of laparotomies infiltration of the line of incision will suffice as a rule. Starting from one or two points of insertion, the needle is directed under the subcutaneous tissues and the fascial

tissues into the muscles, and finally above the surface of the peritoneum. The latter can be infiltrated percutaneously quite easily in patients that are not too stout. Should this not be possible on account of the thickness of the layer of adipose tissues, the peritoneum may be left to be dealt with by subfascial infiltration subsequent to the skin and fat having been opened by incision. In this manner it is possible to anæsthetize most laparotomy incisions satisfactorily; the operator must, however, become accustomed to the imbibition of the tissues with the fluid and the slightly obscured field of operation thereby produced.

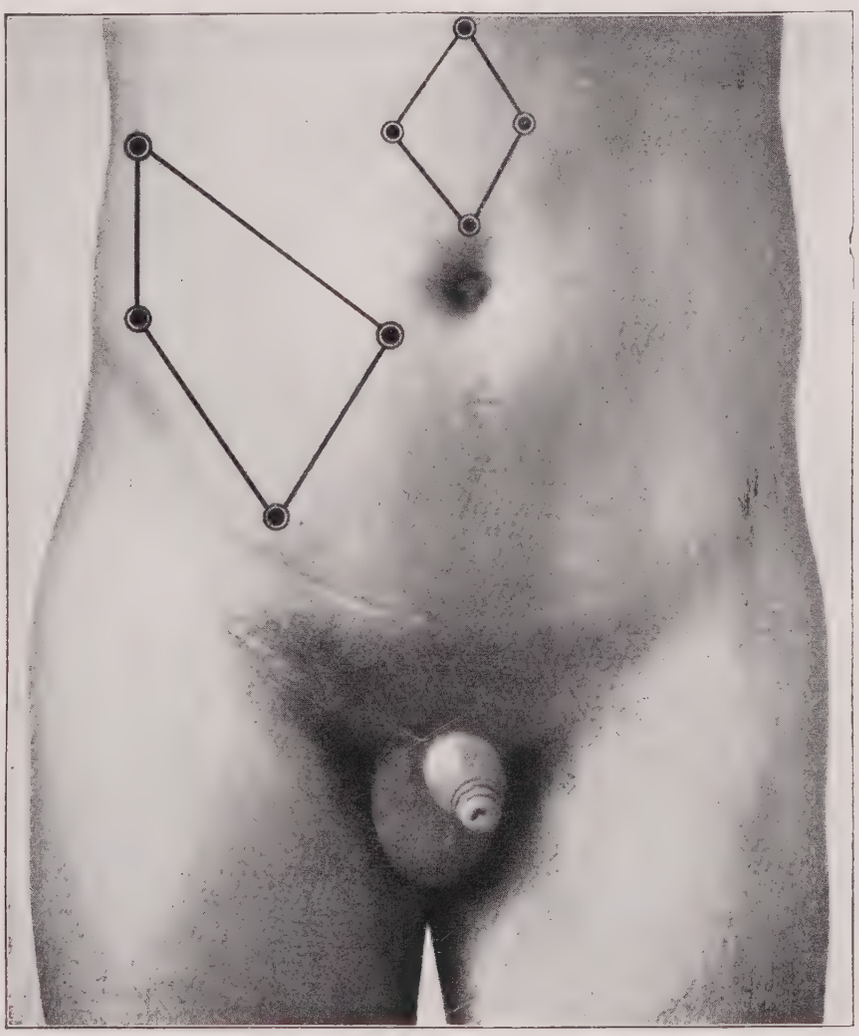

FIG. 60.—Infiltration for abdominal operations. (Laparotomy and appendicitis.)

An **alternative method** is to circumscribe the field of operation by a rhombus, two or four points of insertion sufficing for this purpose. Fig. 60 shows such a rhombus in the median line. Braun advises injecting the field of operation from five points, thus forming a pentagon round it. He uses 100 to 150 c.c. of 0·5 per cent. solution of novocain-suprarenin solution for the purpose. The advantage of anæsthetizing so wide an area of the abdominal coverings by circum-injection is that the edges of the wounds can be retracted more satisfactorily by means of tenacula without causing any pain.

(a) Operations for Umbilical Hernia, Epigastric Hernia, and Post-operative Herniæ.

By means of these rhomboidal and pentagonal circum-injections umbilical and post-operative herniæ may be operated on under local anæsthesia induced in a very simple manner (fig. 61).

In this case also the needle is introduced successively through the various layers of tissues right down to the peritoneum, the circum-

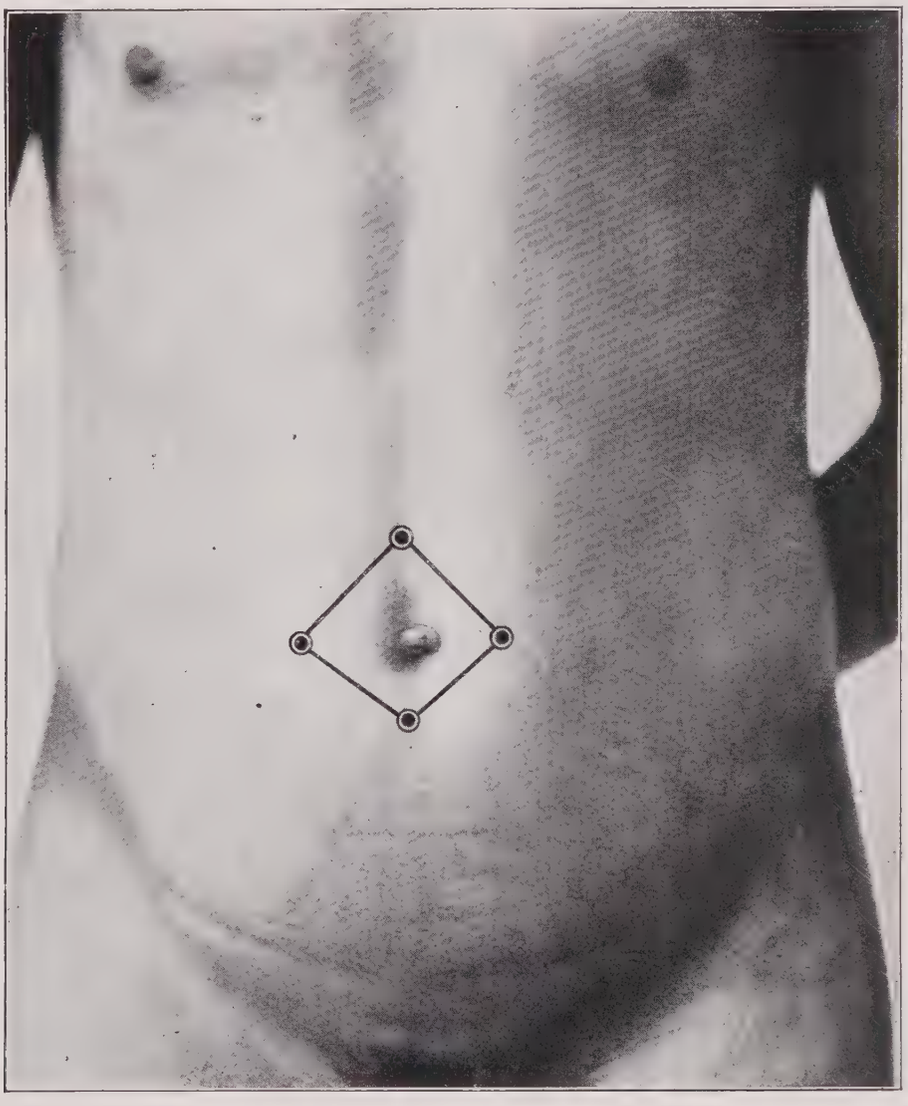

FIG. 61.—Infiltration for umbilical hernia.

scription of the field being carried out well wide of the hernia. In very fat patients the preperitoneal injection may offer some difficulty, and it may then be necessary to anæsthetize the peritoneum at a later stage. The amount of solution requisite will depend on the size of the hernia, and it is therefore better to employ the 0·5 per cent. novocain-suprarenin solutions. Braun has had to inject as much as 250 c.c. of 0·5 per cent. solution in cases of extensive umbilical hernia.

If on opening the peritoneum adhesions be found, as is com-

monly the case in post-operative hernias, complete anæsthesia may be secured by injecting into the adhesions.

(b) Operations for Appendicitis.

Local anæsthesia in appendicitis operations was recommended particularly by Hesse, and later by Colmers and Stenglein ; no doubt many other such attempts were made without their being published. This section of local anæsthesia cannot be regarded as finally settled ; complete anæsthesia cannot be obtained in the majority of cases, and it is only certain particularly favourably situated morbid conditions of the appendix that are suitable for local anæsthesia.

Thus Hesse classifies the cases of appendicitis favourable for local anæsthesia as follows : (1) All straightforward cases of appendicitis during the interval ; (2) mild chronic cases ; (3) severe and mild acute cases in the early stage of the first attack or of an attack that may be regarded as being practically the first.

Unsuitable cases are according to him : (1) All abscesses ; (2) all cases in which pathological-anatomical complications may be expected to be present. By these very obvious conditions a large proportion of appendicitis cases is excluded. More particularly in the acute cases in the early stage local anæsthesia is least of all indicated, since it is recognized that inflamed tissues are more difficult to anæsthetize than normal ones ; further severe pain is caused when separating even small adhesions. Hence it is not rare to find that an operation for appendicitis is commenced under local anæsthesia, and as soon as the abdomen has been opened general anæsthesia has to be induced for the completion of the operation.

To anæsthetize the site of the incision through the abdominal wall it is necessary to circum-inject the field of operation widely. Braun advises that this should be done in the form of a square or rhomboid from four points of puncture, as shown in fig. 60. As the main innervation is from the side, the injections should be carried into the separate layers of tissue, more particularly from the three lateral points.

The technique is the same as that above described for umbilical and epigastric herniæ. Conduction-anæsthesia is out of the question, the nerves must be anæsthetized by infiltration and diffusion of the tissues. For the anæsthetization of the abdominal wall including the preperitoneal tissues 0·5 c.c. of 1 per cent. solution of novocain-suprarenin may be used ; since amounts of 100 c.c. or more may be required the weaker solution is to be preferred. It renders exactly the same service as the stronger in these cases.

After circum-injection of a sufficiently large field the incision may be selected as desired. As soon as the peritoneum has been opened it

will be seen whether the operation can be continued under local anæsthesia or not.

To relieve the pain caused by freeing the appendix and removing it, Hesse suggests injecting the mesentery.

Braun is of opinion that by previously administering morphia and scopolamine these pains may be diminished or even avoided. As we have already stated, Colmers advises the administration of pantopon and scopolamine previous to the operation, and veronal the evening before. The combination of these narcotics, especially in full doses, in itself produces a certain amount of narcosis, which of course greatly aids the local anæsthesia. Should the question of local anæsthesia in abdominal operations not be solved satisfactorily the use of these drugs as adjuvants will be indispensable.

The use of local anæsthesia in **operations on the stomach, intestines and gall-bladder** has already been mentioned above. Here again it is only applicable in certain cases, and then as a rule only with the additional help of narcotics. Most operators perform some of these operations under local anæsthesia, for instance, resections of the stomach, gastro-enterostomies, cholecystostomies, &c.; still more suitable are colostomies and enterostomies, as the segment of intestine that has to be sutured to the abdominal wall is often favourably situated. Local anæsthesia for the latter purpose can be particularly recommended in cases of intestinal obstruction, where the patient is weak and therefore not likely to bear the general anæsthetic well.

In the case of **extensive and protracted laparotomies,** for instance resection of the stomach and intestine, local anæsthesia may be satisfactorily combined with general narcosis. The latter is then substituted when the former fails. The abdomen having been opened under local anæsthesia, ether or chloroform may be administered until the painful manipulations of the stomach or intestine have been completed. When the organs are ready for suturing the painful part of the operation is over, and the rest of the operation can be carried out without general anæsthesia. The stage of excitement at the commencement of the general narcosis may be avoided by previous administration of morphia.

As will appear from what has been said above respecting local anæsthesia in laparotomies, attempts in this direction have not yet led to a satisfactory solution of the problem. We have so far not yet discovered any certain method of causing loss of sensitiveness in the abdominal organs by means of local injection of anæsthetizing solutions. The spinal and epidural methods of inducing anæsthesia, which must also be included among conduction-anæsthesias, form an exception. It is therefore the obvious wish of all who are interested in local anæsthesia to find a solution for this as yet unsolved problem.

There has been no lack of attempts to do so. Already in 1905

Sellheim attempted to anæsthetize the intercostal nerves near their ganglions at the point of emergence from the spinal cord. Laewen tried the method in hernia operations. Neither of them had much success.

These attempts have been repeated, especially quite recently, when the question of local anæsthesia became an important one on account of the success that was attending its use, a success which did not extend to abdominal operations.

This is not the place to enter into the great question of the sensitiveness of the abdominal organs. As is generally known, it is more especially the manipulation of dragging on the mesentery which causes the great tenderness that renders operations on the abdominal organs almost impossible unless performed under general anæsthesia. Of like importance is the pain caused by squeezing and pinching the mesentery, which renders both removal by ligature and simple ligature of this tissue so painful. Once such organs as the stomach, intestine, &c., have been drawn forward into position and there fixed, the rest of the operation can be carried out painlessly, at least in the case of the stomach and intestine.

Paravertebral Conduction-Anæsthesia.

The tendency of more recent investigations has been to attempt to interrupt the conduction of the nerve-fibres that supply the sensory innervation to the mesentery. The communicating branches of the spinal nerves go to the sympathetic ganglia and thence supply the sensory innervation. These ganglia are situated in close apposition to the bodies of the vertebræ (fig. 54). The vertebral foramina through which the spinal nerves emerge are situated below the transverse processes as viewed from the front and side. We have therefore some guides for directing the needle, and recent experiments have been directed towards interrupting the conduction of the spinal nerves and their branches to the sympathetic at this point. It is more particularly Kappis and Finsterer who have investigated this problem, and they have reported some successful results. Paravertebral anæsthesia, as this procedure is termed, can hardly as yet be designated as a definite method.

Kappis describes the following **technique for injecting at the intervertebral foramina**, based on his experiments both on the dead and living subject.

Since paravertebral conduction-anæsthesia can only be performed

on one side in the cervical region on account of the phrenic nerve, and since further it is just in this region that it can be dispensed with, we shall in this section discuss paravertebral anæsthesia as applied to the thoracic and abdominal regions only. The scope of the procedure extends from the first intercostal to the fourth lumbar nerves.

Kappis introduces the needle vertically about 3·5 cm. from the mid-dorsal line in the direction of the rib or transverse process. At about 4 to 5 cm. depth the bone is encountered; keeping touch with the latter along its lower border a point is reached between the transverse process and the lower articular process at which the nerve lies. The needle should not be pushed vertically into the deeper tissues from the lower border of the bone, but should be inclined at an angle of 20° to 30° towards the median line, and should besides be advanced medially for about 1·5 cm. from the border of the bone. At this spot 5 c.c. of 1·5 per cent. novocain-suprarenin solution are injected.

According to Kappis all the dorsal and the first four lumbar nerves can be injected by this method; only in the case of the fifth lumbar is some difficulty caused by the anatomical relations of the osseous structures. Kappis recommends his method for operations on the thorax and kidney, and abdominal operations such as resections of the stomach, cholecystectomies, &c. The anæsthesia commences after ten to fifteen minutes and lasts for one and a half hours.

At about the same time as Kappis, **Finsterer** was working at the solution of this problem. His technique is as follows: By palpation the position of the spinous process of the first lumbar vertebra is determined, and about 3 to 3·5 cm. external to the middle line, an endermic cutaneous wheal is raised by injection. From this point an injecting needle marked in centimetres is introduced vertically and pushed into the tissues for about 4 to 5 cm. until the transverse process of the first lumbar vertebra is encountered. Then feeling along the upper border of that process with the needle the latter is pushed onwards towards the middle line and upwards for about 0·5 to 1 cm., the syringe being lowered and directed somewhat outwards. At this point 5 c.c. of 1 per cent. novocain-suprarenin solution are injected. The injections at the other vertebræ are made in an analogous manner. In order to put out of action the anastomoses of the higher intercostal nerves Finsterer infiltrates the subcutaneous tissues. Anæsthesia supervenes in about fifteen minutes.

Finsterer reports only four cases in which anæsthesia was obtained by this method of injection (peritonitis, ileocolostomy, breaking down of adhesions at the splenic flexure of the colon and appendicitis).

It is evident, therefore, that this form of local anæsthesia is still

in its initial stages and it is not possible as yet to foretell whether there is likely to be any future for it. The disadvantages seem to preponderate considerably over the advantages, and hence its adoption can hardly be recommended. As is evident from the above description, the technique is highly complicated. Deep and by no means painless injections have to be made from several points of puncture, and the demands made on the psyche of the patient are comparatively severe. For this reason Kappis recommends that scopolamine and morphia should be administered to the patient before injecting, in order to calm him. The injections are not free from risk, for if one approaches too near the intervertebral canal the solution may diffuse towards the meninges and lead to collapse.

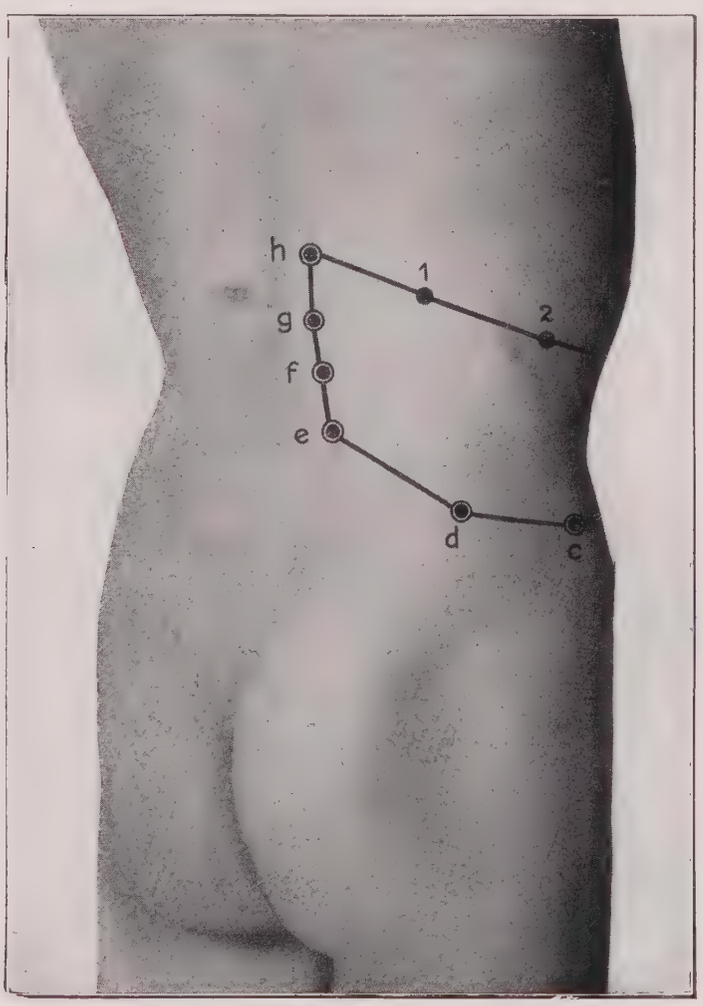

FIG. 62.—Injection for renal operations.

Local Anæsthesia in Kidney Operations.

Laewen combined paravertebral anæsthesia with retro-peritoneal anæsthesia for rendering the kidney and its surrounding tissues insensitive. The method has so far only been applied by him in one patient, the result being satisfactory. The method is as follows:—

From four infiltration wheals on the skin (figs. 62 and 63, *a*, *b*, *c*, *d*)[1] situated on a curved line running parallel and about two finger-breadths internal to the crest of the ilium, the long needle is inserted down to the bone, and then again withdrawn for about 1 to 2 cm. and the point turned inwards and upwards. From each point 20 c.c.

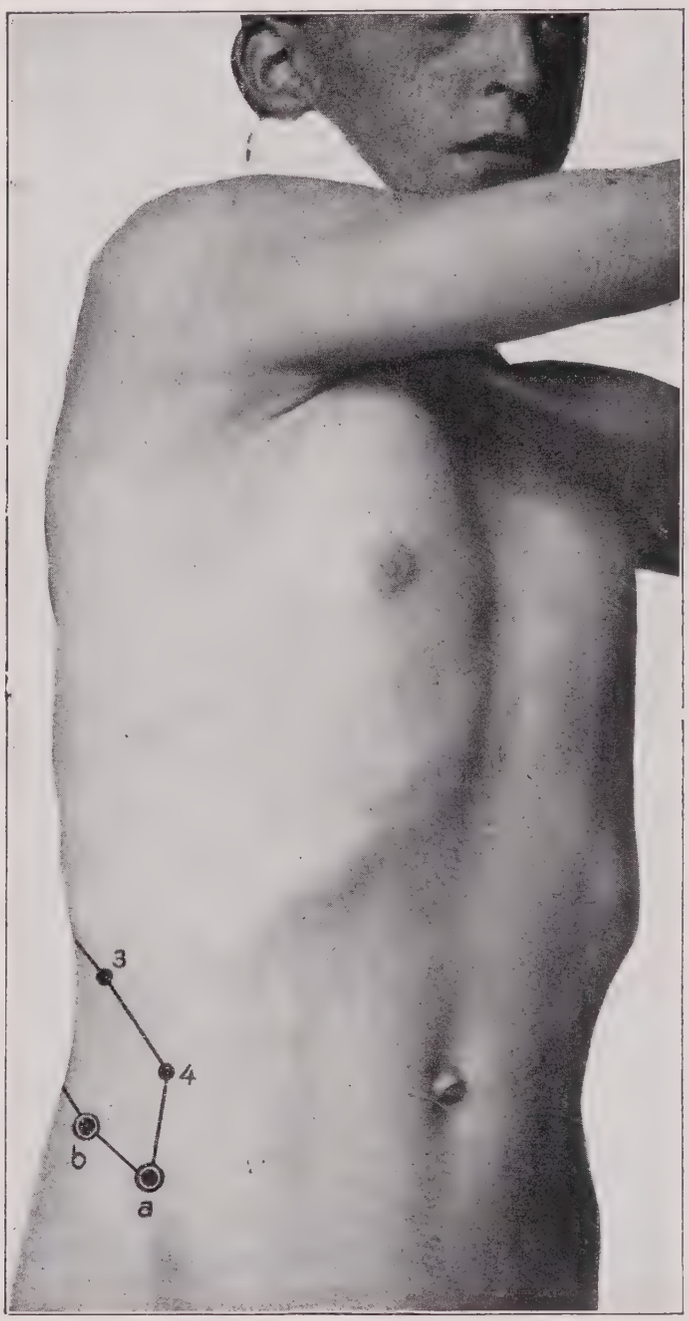

FIG. 63.—Injection for renal operations.

of 0·5 per cent. solution of novocain-bicarbonate adrenalin are injected. Then from each of four other points (fig. 62, *e*, *f*, *g*, *h*) distant 4 cm. laterally from the middle line of the spine, 10 c.c. of a 1 per cent. solution of the same are injected at the points of emergence of the

[1] The points surrounded by a circle represent deep injections, whereas simple points indicate subcutaneous injections.

twelfth intercostal and the first to fourth lumbar nerves. Finally, the probable line of incision is circumscribed by subcutaneous injections.

Laewen reaches the region of the intervertebral foramina as follows: The needle is introduced 4 cm. external to the upper angle of the spinous processes between the transverse processes, and turned somewhat inwards, the anæsthetic being injected at this point.

Further experience with Laewen's method for kidney operations is required before a final judgment as to its value can be given. The great drawback to the procedure is that it is complicated; it might be given a trial in cases in which general anæsthesia is definitely contra-indicated.

Kappis also recommends paravertebral anæsthesia for operations on the kidneys, employing his method as described above. He injects from the eighth dorsal to the first lumbar, or, if the ureter be involved, also at the second and third lumbar vertebræ. By this method he obtains complete anæsthesia of the skin, muscles, and the adipose capsule of the kidney, but the peritoneum and the actual freeing of the kidney are not entirely painless. Nevertheless, he manages to complete the operation without general anæsthesia.

Colmers also reports experiments with local anæsthesia for operations on the kidneys.

Local Anæsthesia in Operations on the Vertebral Column (Laminectomy).

For **laminectomies Braun** advises circumscribing the area to be operated on by injecting 0·5 per cent. solution of novocain-suprarenin. His object is to induce bloodlessness by the action of the suprarenin, so that the operation need not be undertaken in two sittings. During the actual operation he applies general anæsthesia. Starting from about eight points that circumscribe the field of operation, he inserts the needle as far as the transverse processes of the vertebræ and injects 0·5 per cent. solution; finally, the points are united by subcutaneous injection. As he injects merely to prevent excessive loss of blood, suprarenin solution without added novocain would be sufficient for the purpose.

Heidenhain has shown that laminectomy can also be performed under local anæsthesia alone. He describes the method as follows: The highest and lowest point of the skin incision are each indicated by an infiltration wheal over the spinous processes. The skin between these two points is then circumscribed by injection in the shape of

an extended rectangle, the two longer sides of which are situated three fingers' breadth from the middle line on each side. At each spinous process close to its lateral surface the needle is introduced until it reaches bone, then it is pushed, half inclined and steeply inclined, outwards on to the surface of the vertebral arch, likewise inclined upwards and downwards into the spaces between the arches. From the same points the arches of the vertebræ above and below are anæsthetized by inclining the direction of the needle. A considerable quantity of 0·5 per cent. novocain-suprarenin solution is required for the injection; it may amount to more than 250 c.c.

Local Anæsthesia in Operations for Inguinal Hernia, Hydrocele, Testicular Disease, and Femoral Hernia.

One of the first major operations performed under local anæsthesia, and probably still one of those in which it is most frequently used, is herniotomy.

It is in operations for hernia that local anæsthesia can best be studied and learnt. In these cases, particularly where inguinal herniæ are concerned, we employ conduction-anæsthesia in the majority of instances, interrupting the conduction of three main nerve-trunks; a part of the anæsthesia must also be obtained by infiltration.

Already at the time when cocaine was employed for local anæsthesia (1889) Reclus used it for all his herniotomies, injecting about 14 to 18 c.c. of 1 per cent. cocaine solution for each operation.

Hackenbruch used to circum-inject the hernia subcutaneously with a mixture containing 0·5 to 1 per cent. each of cocaine and eucaine. He made similar injections at the neck of the hernia and into the soft parts at the entrance to the hernial sac. Schleich also operated on hernia under local anæsthesia.

Cushing split the fascia of the external oblique muscle above the external inguinal ring, sought for the three nerve-trunks that have to be taken into account, and injected 1 per cent. solution of cocaine endoneurally.

Bodine became an adherent to this method; Leander also injected either into the nerve-trunks or in the neighbourhood of their course.

Braun was the first to elaborate a method complying with all the modern demands of local anæsthesia, and applicable in all cases of

herniotomy. Later Nast-Kolb and v. Lichtenberg pointed out some modifications of this method.

The nerves that have to be considered in the case of inguinal, and partly also of femoral, hernia are three in number, the ilio-inguinal, the ilio-hypogastric and the genito-femoral (genito-crural) nerves. One may also occasionally meet with the cutaneous branches of the last intercostal nerve (fig. 64).

FIG. 64.—The nerves of the inguinal region. *a*, Rami cutanei ant. N. intercost. XII. *b*, N. genito-femoralis. *c*, N. ilio-hypogastricus. *d*, N. ilio-inguinalis.

The ilio-inguinal nerve arises from the lumbar plexus and runs near the ilio-hypogastric nerve laterally, to pierce the tendon of the transversus abdominis muscle directly above the posterior part of the iliac crest, and then proceeds in an anterior direction between the muscles of the abdominal wall. It thus reaches the external oblique muscle, remaining under the fascia. It gives off sensory branches to the peritoneum, as well as muscular branches to the abdominal muscles. It anastomoses with the ilio-hypogastric nerve and then emerges on the anterior superior surface of the spermatic cord through the external inguinal ring. Here it gives off the branches to the thigh which anastomose with the branches of the spermatic nerve, also anterior scrotal (labial) branches to the lower part of the mons

pubis, and to the superior anterior part of the scrotum (labium majus).

The ilio-hypogastric nerve is derived from the twelfth dorsal and first lumbar nerves, is thicker than the ilio-inguinal, and corresponds like the latter to an intercostal nerve in its distribution. It runs laterally and downwards behind the lower part of the kidney towards the tendon of the transversus abdominis muscle, which it pierces above the iliac crest. At first it courses between the latter muscle and the obliquus internus close above the iliac crest, later between the oblique muscles above the inguinal (Poupart's) ligament, to enter the sheath of the rectus abdominis. It anastomoses with the ilio-inguinal nerve. In its course between the muscles it gives off muscular branches and some to the peritoneum. Its terminal distribution is mainly to the skin of the inguinal region.

The genito-crural nerve is derived from the first and second lumbar nerves; passing in front of the psoas muscle behind the peritoneum and downwards behind the ureter it divides into two branches: (1) the lumbo-inguinal nerve (crural branch) which runs downwards external to the external iliac artery and gives off a branch to the N. cutaneus femoralis lateralis (external cutaneous) and to the ilio-inguinal nerve through the transversus abdominis muscle. It then emerges externally and anteriorly to the femoral artery at the lacuna vasorum and reaches the fossa ovalis. (2) The N. spermaticus externus enters the inguinal canal through the internal abdominal ring or through the posterior wall of the inguinal canal and runs along the posterior inferior surface of the spermatic cord to emerge at the external ring and to be distributed to the cremaster muscle, to the tunica dartos, to the skin of the scrotum (labium majus) and to the superior medial portion of the thigh.

The three main nerves, the ilio-inguinal, ilio-hypogastric and genito-crural, anastomose among each other and can therefore replace each other, one or two of them may be missing ; the most constant seems to be the ilio-hypogastric. The two lowest, the genito-crural and lumbo-inguinal are not encountered when dealing with inguinal herniæ, but they are of importance in the case of femoral herniæ.

By means of subfascial and intramuscular injections of the trunks of these three nerves anæsthesia may readily be induced.

Since Braun's method of anæsthetizing inguinal and femoral herniæ is very simple and easily carried out it can be strongly recommended.

(a) Anæsthesia for Reducible Inguinal Hernia.

Braun (fig. 65).

Two points of puncture are indicated by two infiltration wheals. Point 1 is situated three finger-breadths internal to the anterior

superior iliac spine, point 2 on the horizontal ramus of the pubis. From point 1 the muscles and subfascial spaces are infiltrated in the direction indicated by the arrow *a*, and the conduction of the above mentioned nerves thereby interrupted. From the same point the hernial entrance is infiltrated subfascially in the direction of the arrows *b* and *c* to the right and left. From point 2 injections are

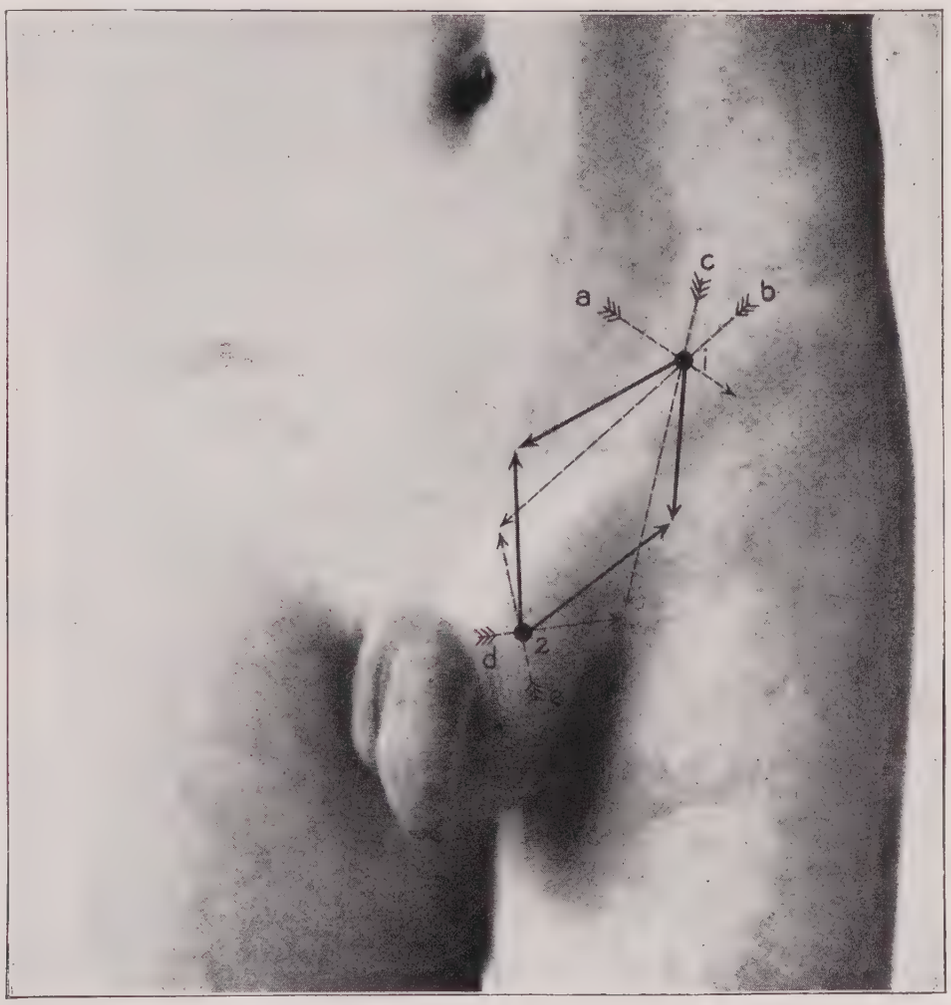

FIG. 65.—Injection for reducible inguinal hernia.

made on to the pubic bone round the entrance to the hernial sac and into the inguinal canal (arrows *d* and *e*). Finally, the skin is circumscribed in the form of a rhombus (not dotted arrows). Braun uses 75 to 100 c.c. of 0·5 per cent. solution of novocain-suprarenin for a hernia operation.

If two herniæ have to be dealt with, it is best to inject both at once and commence the operation on the side first anæsthetized.

(b) Anæsthetizing Method for Irreducible Hernia.

Braun (figs. 66, 67).

As will be seen from fig. 66 the subfascial and intramuscular injections are carried out in a manner identical with that described for the reducible forms from point 1. From points 2 and 3 injections

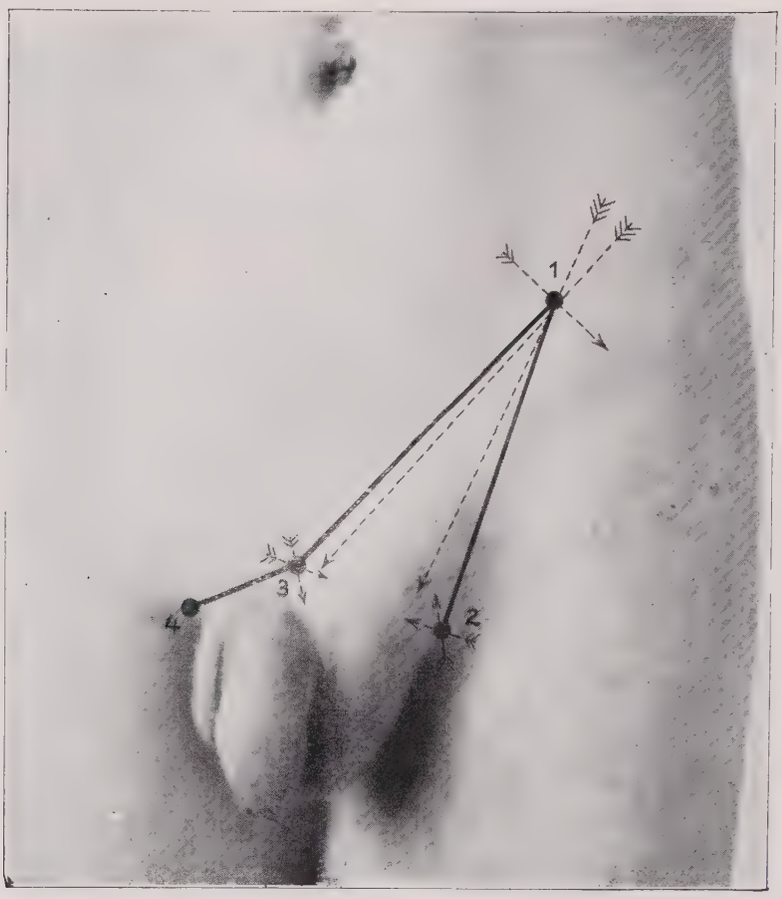

FIG. 66.—Injection for irreducible inguinal hernia.

FIG. 67.—Injection for irreducible inguinal hernia.

are made under the hernial sac and into the neck of the sac; hence the hernia must be drawn to the right and left as well as upwards whilst the injection is being made. Since the posterior surface of the scrotum is also involved in the operation, this must also be circumscribed by subcutaneous injection from the points 2, 4 and 3 as indicated in figs. 66, 67. About 120 c.c. of 0·5 per cent. solution of novocain-suprarenin will be required.

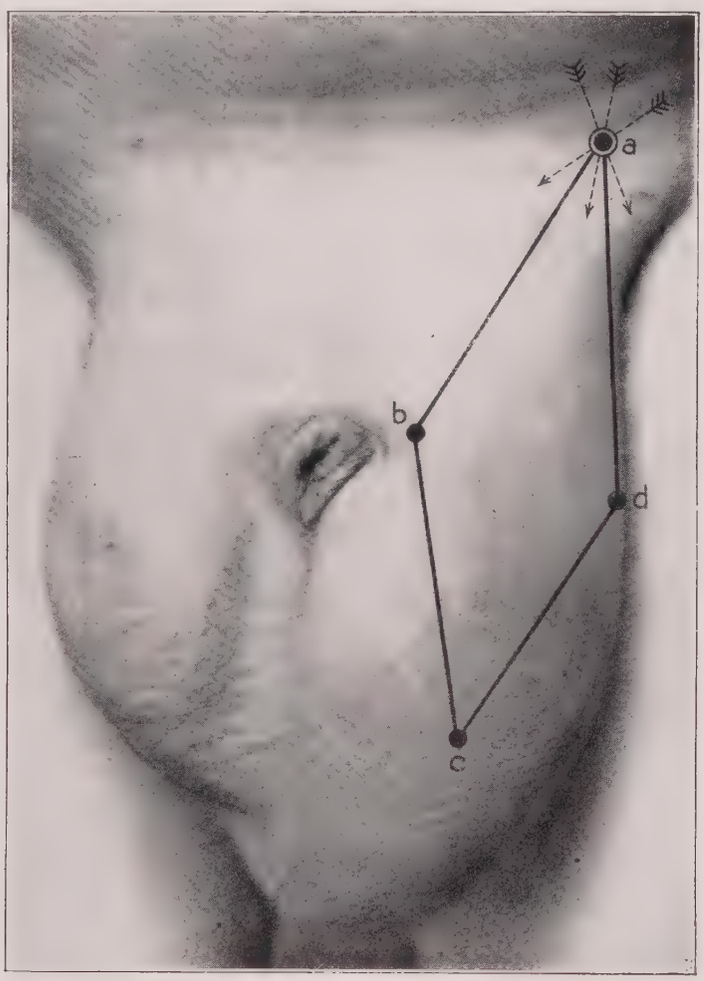

FIG. 68.—Injection for hydrocele.

(c) Method of Anæsthetizing for Hydrocele, Varicocele, and Operations on the Testicle.

(Fig. 68.)

If one has to deal with uncomplicated hydrocele operations (Winkelmann) or resections of varicocele, the infiltration may be carried out as shown in fig. 68. From the point *a* the muscles and spermatic cord are anæsthetized by several syringefuls of 0·5 to 1 per cent. novocain-suprarenin solution in the directions indicated by the dotted arrows. Finally, the subcutaneous tissue is infiltrated with the same solution in the shape of the rhombus, *a*, *b*, *c*, *d*, using several syringefuls. If, on the other hand, large

adherent hydroceles have to be dealt with, in which the tunica has to be removed as well, or in the case of castrations in which there are adhesions to the scrotum (tubercular testicle), this method is inadequate and it will be necessary to interrupt the conduction of the posterior scrotal nerves by subcutaneous infiltration around the scrotum and the root of the penis, as has been described when dealing with irreducible herniæ (Braun, figs. 66, 67).

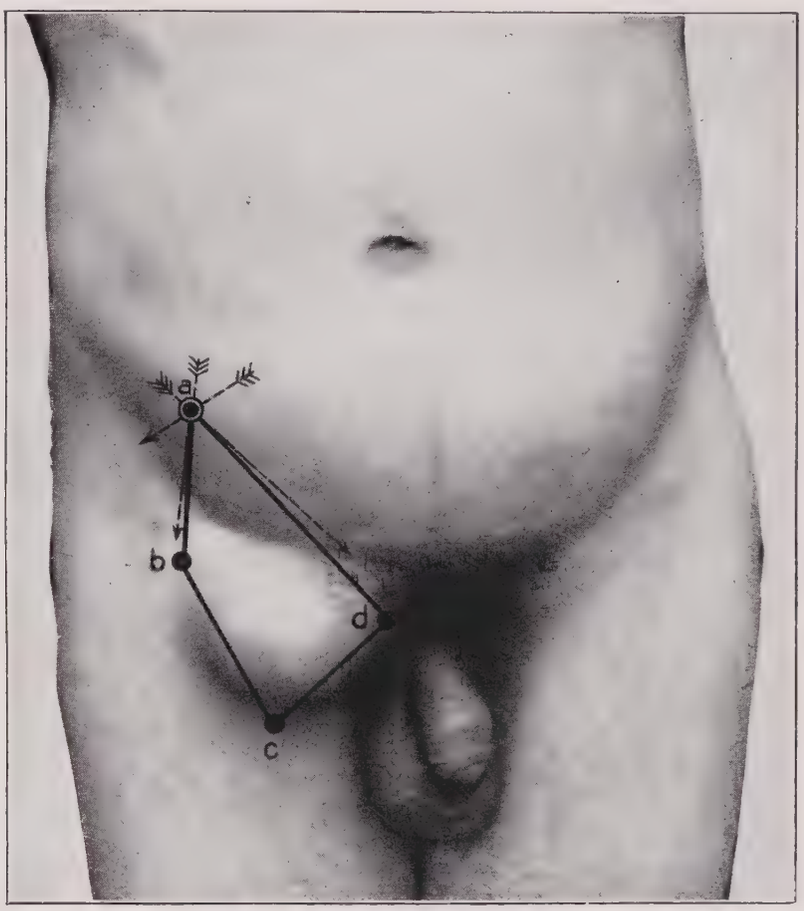

Fig. 69.—Injection for femoral hernia.

(d) Method of Anæsthetizing for Femoral Hernia.

Braun (fig. 69).

From point *a* the muscles and subfascial space are infiltrated transversely (transverse arrow) in a manner identical with that described under inguinal hernia, with a view to interrupting the conduction of the genito-crural nerve, which has to be taken into account more particularly in the case of femoral hernia. The two longer arrows directed towards the thigh indicate deep subfascial infiltration external to the spermatic cord. From points *b*, *c*, *d*, deep injections are made towards the hernial sac. Finally, the four points are united by subcutaneous infiltration. The quantity of fluid injected amounts to about 75 c.c. of 0·5 per cent. solution, as in the case of inguinal herniæ.

The technique employed for obtaining anæsthesia in the case of hernia, especially of inguinal hernia, can of course be varied; there are many possible ways of injecting so as to obtain satisfactory results as regards the anæsthesia.

Braun's methods have been mentioned here as typical; they are simple and easy of performance, and satisfactory anæsthesia of the tissues to be operated on is attained by them with certainty.

We shall also describe Hohmeier's method, which is likewise simple and satisfactory in its results. It has the further advantage that all the injections are made from one point of puncture.

The author, who also tries to employ as few points of puncture as possible, has for some time employed a method very similar to that of Hohmeier, and has been very satisfied with it.

Hohmeier's method of injecting simple reducible herniæ is as follows: After reducing the hernia and defining the position of the external inguinal ring, the needle is introduced below the latter and pushed onwards into the inguinal canal under guidance of the finger. An injection is made here whereby the conduction of the ilio-inguinal nerve is interrupted. The needle is then slightly retracted and introduced medially and laterally into the internal oblique muscle, which is infiltrated on both sides. The needle is now withdrawn from the inguinal canal, but still remains in the same point of introduction in the skin, and the subcutaneous tissues upwards and over the inguinal canal are now infiltrated by radiating fan-like injections. The needle is then turned downwards, and the subcutaneous tissues inferior to the point of puncture infiltrated in the same fan-like manner. In order that the external spermatic nerve may be reached more easily, Hohmeier advises lifting the spermatic cord with two fingers; the needle is introduced behind it and pushed on for about 5 cm. along Poupart's ligament; the injection is made as the needle is slowly withdrawn. By this means the lumbo-inguinal crural branch of the genito-crural nerve also comes into contact with the anæsthetic. Finally, the line of incision is infiltrated upwards and onwards from the same point of insertion. There is perhaps one drawback to the method, namely, that the injection of the line of incision may obscure the field of operation owing to the imbibition of the tissues. This disadvantage can, however, only affect operators who are not yet accustomed to operating under these conditions.

Local Anæsthesia in Operations on the Penis and the Female Genitalia.

The nerve that has mainly to be considered when producing local anæsthesia of the penis is its dorsal nerve. This is a branch of the N. pudendus (pudic nerve), which divides into two branches at the ischial tuberosity, the perineal and dorsalis penis nerves. The latter reaches the dorsum of the penis between the transverse ligament of the pelvis and the ligamentum arcuatum pubis; in passing it sends off fine twigs to the deep transverse perineus muscle and the sphincter of the membranous urethra and anastomoses with the Nn. cavernosi penis. Having reached the penis, it sends off lateral twigs to the corpus cavernosum and to the skin on the sides and under surface of the organ; in the form of medial deep branches it runs on both sides of the dorsal artery of the penis to be distributed to the glans.

By circular subcutaneous injection of the root of the penis most of the nerves of the penis may be interrupted in their conduction (N. dorsalis penis). But this injection alone will not suffice to completely anæsthetize the penis on account of the anastomoses with the deeper nerves of the corpora cavernosa. These small nerves are derived from the cavernous plexus which belongs to the pelvic plexus of the sympathetic. Krogius had already used subcutaneous circumscribing injections of the penis for operations on the foreskin, but he only succeeded in obtaining partial anæsthesia for the reason just given.

Amputation of the penis can be performed easily under local anæsthesia by combining subcutaneous circum-injection at the root of the organ with deep injections into the corpora cavernosa from the same points of puncture; 20 to 30 c.c. of 0·5 per cent. solution of novocain-suprarenin will be ample.

If the inguinal glands on both sides are to be removed at the same time, anæsthesia of the inguinal region may be attained by rhomboidal circum-injection of the field of operation.

In **operations for phimosis** it is best to circum-inject the prepuce at the coronary furrow (Braun). The prepuce is drawn tightly over the glans and there fixed, either by holding it with the hand or by ligaturing it so that it cannot retract (fig. 70). Injections are then made under the skin into the coronary furrow from 3 to 4 points as shown in the figure. A few cubic centimetres of 0·5 per cent. solution will suffice. As soon as anæsthesia supervenes the ligature is removed and any desired operation for the relief of phimosis is performed.

The **method described by Reclus** is more cumbersome than Braun's. Reclus has the anterior margin of the prepuce held and

stretched. He then injects several cubic centimetres of solution from the dorsal side of the penis along the line of incision between the two layers of the prepuce until he reaches the coronary furrow. Anæsthesia having been obtained, the infiltrated line is incised down to the furrow. The two flaps are drawn sideways, and at their bases injections of the same type between the two layers are made right and left along the furrow to the frænum. After circumcision has been performed as far as this point a final injection is made between the two layers of the frænum to permit of the complete severance of the flaps. The drawback of the method is that it is performed in three sections.

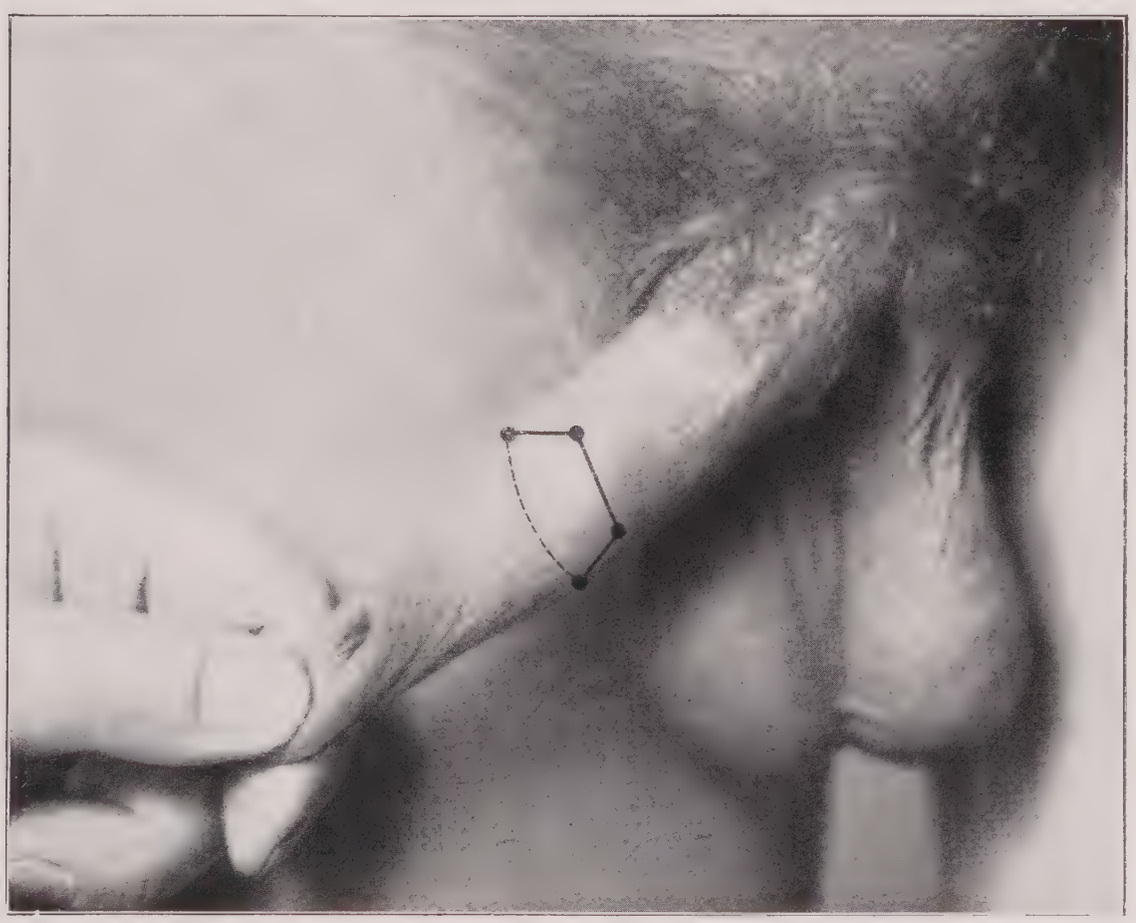

FIG. 70.—Injection for circumcision. (Braun.)

External urethrotomy may be performed in a simple manner under local anæsthesia. A Hackenbruch's rhombus is described round the field of operation from two to four points of puncture. In order to obtain anæsthesia of the deep tissues, several injections are made between the urethra and rectum as well as round the urethra.

The use of local anæsthesia in **gynæcological operations** has not kept pace with that in other fields of surgery. This is probably mainly due to the inaccessibility of the nerves that have to be especially considered when dealing with the internal female generative organs.

In the case of the **external genitalia** it is best to rely on infiltration-

anæsthesia; for conduction-anæsthesia (N. pudendus) is not applicable on account of the very complex innervation of the vulva, unless the operation be absolutely restricted to the neighbourhood of the entrance of the vagina. In performing deeper operations one encounters the sympathetic plexus which can be reached by the needle only with difficulty.

Braun describes the methods of anæsthetizing for the removal of tumours of the external genitalia as well as for perineorrhaphies. For both operations anæsthesia may readily be induced by subcutaneous infiltration round the field of operation. Others (Freund, Fisch, Losinski, Wagner), report colporrhaphies and removal of recto and vesicovaginal fistulæ under local anæsthesia. Henrich and Kraatz refer to local anæsthesia for **operations on the cervix** and **uterine portion of the cervix,** as well as for clearing out the uterus and curetting. Ilmer draws attention to interrupting the conduction of the pudic nerve in operations on the external genitalia. Stimulated by a suggestion of Mueller's, he made the first attempt at **anæsthetizing the pudic nerve.** He felt for the ischial tuberosity and introduced the needle along the posterior surface of that bone; having reached a certain depth, the needle was then guided beneath the ischio-sacral ligament and the anæsthetic injected at this spot. Ilmer used 1 c.c. of 5 per cent. cocaine with 5 to 6 c.c. of sterile physiological salt solution.

Sellheim employed anæsthesia of the pudic nerve for operations in cases of **prolapse and perineal tears.** In obstetrics he obtained relief of pain, especially in the case of forceps deliveries and versions.

His technique is as follows: The point of introduction of the needle is at the side of the anus in the centre of the medially inclined surface of the tuberosity. With the middle finger of the hand which does not correspond to the side of the pelvis that is to be anæsthetized the point of the ischial spine is fixed from the vagina, whilst the index finger of the same hand controls the advancing needle. The pudic nerve is anæsthetized near its entry to the ischio-rectal fossa by injecting considerable quantities of anæsthetic as well as by injecting in various directions in this region (perineural injection).

Ruge attempted total **extirpation of the uterus** *per vaginam* under local anæsthesia. He injected deeply into the parametrium to the right and left of the portio as well as from two points in the anterior and posterior vaginal arch. He twice carried out this anæsthesia successfully. Further experiments in this direction may be expected.

It is to be hoped that epidural injection will become a satisfactory substitute for local anæsthesia in operations on the female genitalia.

Local Anæsthesia in Operations on the Prostate.

The nerve distribution that has to be taken into account in prostatectomy varies according to whether the suprapubic or the perineal method is selected (Young or Wilms); the innervation in either case is somewhat complicated.

The perineal operation is the more suitable for local anæsthesia.

For the **suprapubic operation** Braun recommends that the bladder should be filled with 1 per cent. alypin-suprarenin solution. Into the perivesical space and the abdominal walls he injects 0·5 per cent. novocain-suprarenin solution.

Payr attempted to infiltrate the neighbourhood of the prostate from the bladder.

Lanz performed bilateral suprapubic prostatectomy under local anæsthesia. He first performed suprapubic cystotomy after infiltrating the abdominal wall with two Pravaz syringefuls of 1 per cent. cocaine solution having 6 drops of 11 in 1,000 adrenalin added. The enucleation of the prostate was performed at a second sitting without any anæsthesia and gave but little pain.

Kayser adopted the same method except that he employed 1 per cent. novocain solution instead of cocaine.

Hohmeier recommends that in addition to the infiltration of the abdominal walls the periprostatic tissues should be injected, the needle being guided by the finger introduced into the rectum. Colmers injected in a like manner, but assisted the local anæsthesia by the administration of pantopon, scopolamine and antipyrin enemata. These isolated attempts at performing suprapubic prostatectomy under local anæsthesia cannot be said to have solved the question satisfactorily. No certain and generally applicable method has as yet been devised. In any case local anæsthesia for suprapubic prostatectomy (as well as for the perineal operation) can in the majority of cases be replaced by lumbar or extradural anæsthesia.

Far more favourable is the chance of inducing local anæsthesia in **perineal prostatectomy** according to Young's or Wilms's methods.

In this case we are mainly concerned with the pudic nerve, the anæsthetizing of which, as we have already seen, has been tried with some success in gynæcological cases. Franke and Posner were the first to elaborate it into a truly practical method in perineal prostatectomy.

Besides the pudic nerve we have to consider the pelvic nerve coming from the sacral sympathetic plexus (fig. 71). According to Froehlich and H. Meyer the sympathetic contains no sensory elements.

On each side of the perineum a few twigs of the N. cutaneus femoris posterior (small sciatic) have to be taken into account.

According to Franke and Posner, the pudic nerve is easily struck where it takes its course on the dorsal surface of the ischial spine. At this spot the nerve is close to the bone lying in loose connective tissue, whereas in its further course it lies under the obturator fascia.

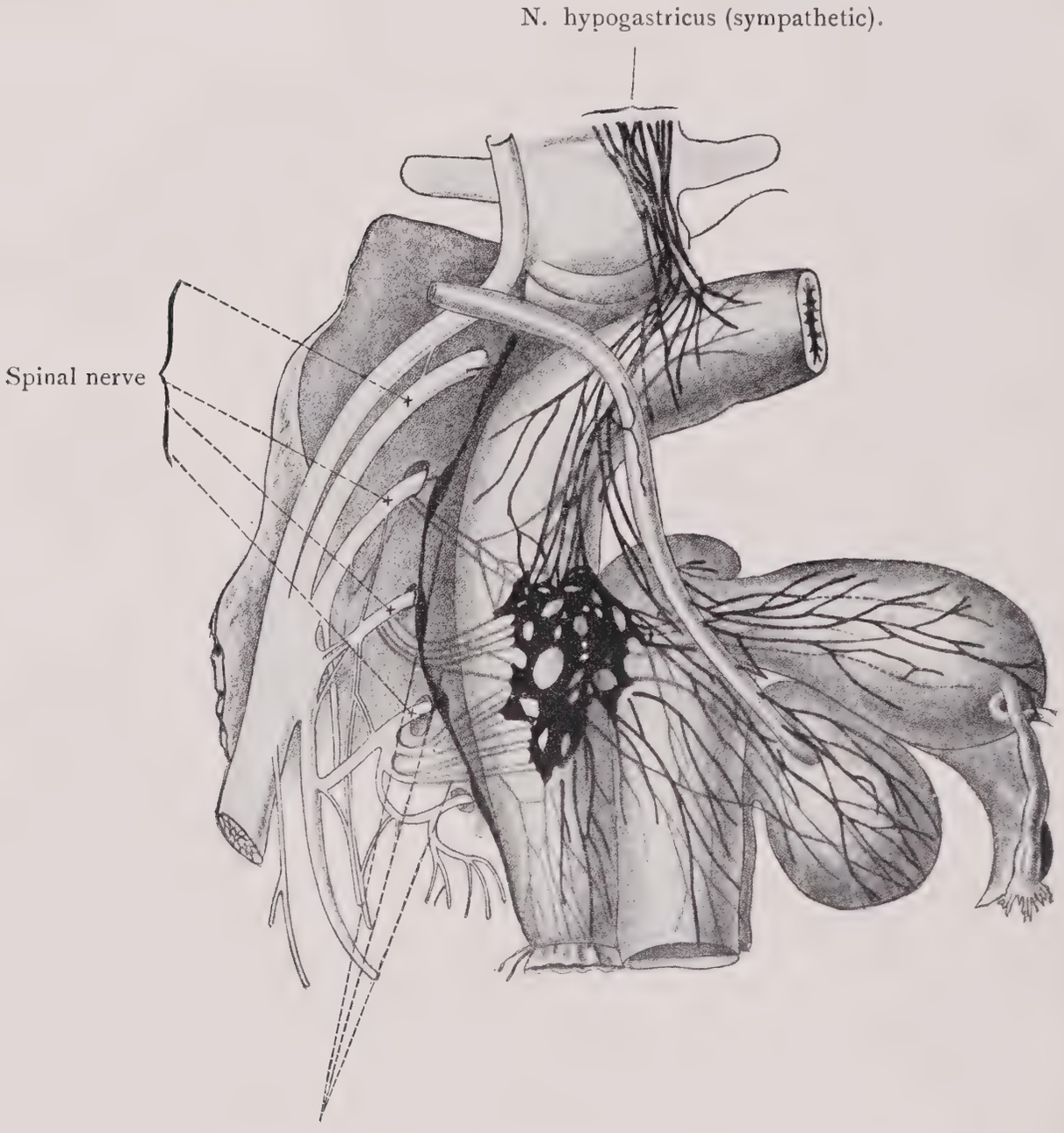

FIG. 71.—Sacral sympathetic plexus.

This fascia can hardly be penetrated by the anæsthetizing solutions. The course of the pudic nerve is shown in fig. 72.

The technique described by Franke and Posner is as follows : A 1 per cent. solution is used. In the perineal region 2 to 3 cm. laterally from the middle line, and a little to the ventral side of the anus infiltration cutaneous wheals are made on each side. The index

finger of the left hand is then introduced into the rectum, the sacrum is felt for, and passing along the easily palpated sacro-spinous ligament the ischial spine is sought for. A 12 to 15 cm. long hollow needle is now introduced through the wheal made on the left side of the patient

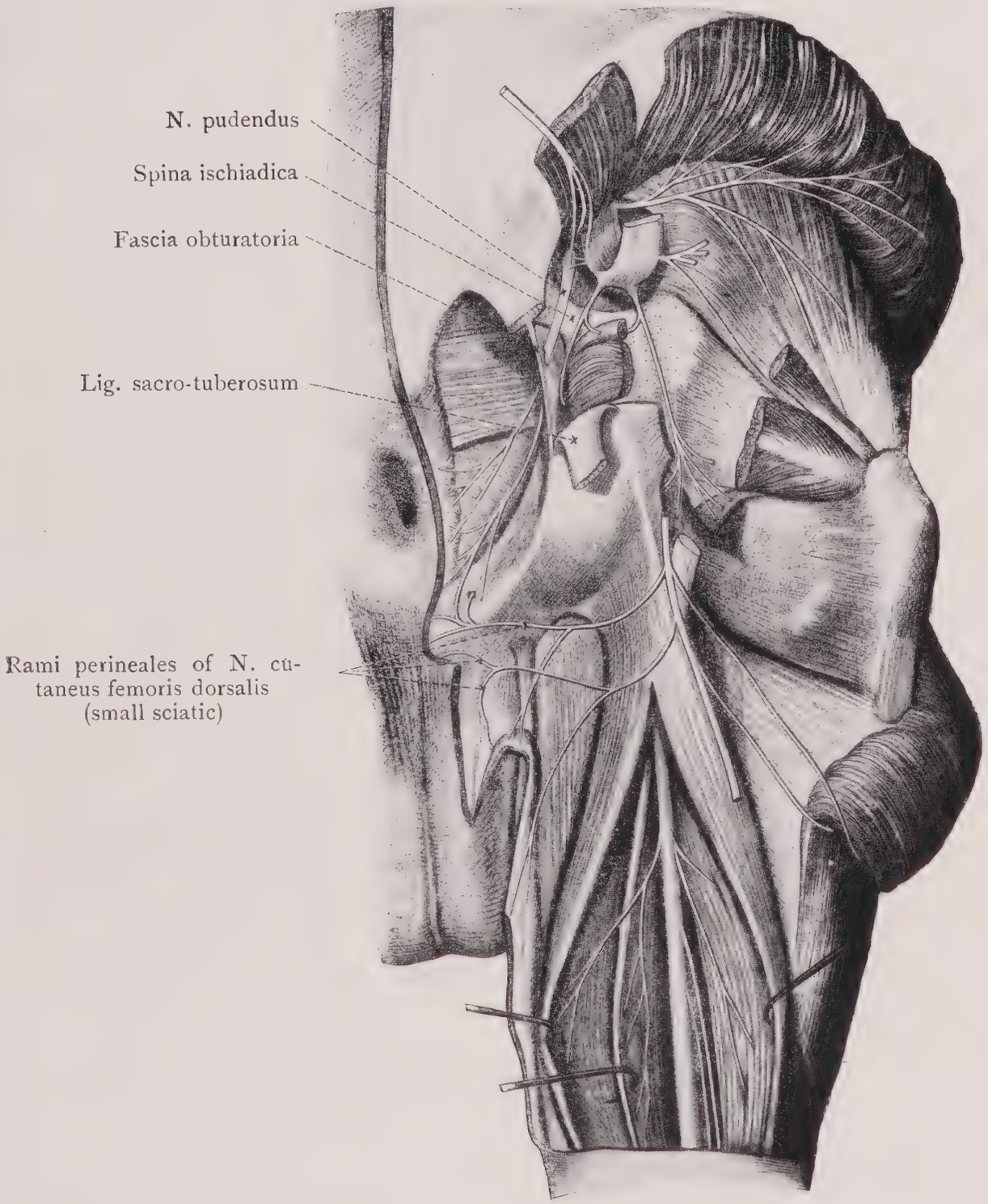

FIG. 72.—(After Toldt.)

and pushed onwards in the direction of the longitudinal axis of the latter. A certain amount of resistance is now met with, and the patient will complain of pain; the point of the needle has reached the floor of the pelvis (levator ani). A few cubic centimetres of the solution are injected here, and the needle is then pushed onwards,

guided by the finger in the rectum, until it reaches the spine of the ischium; the correct point being found by striking on the bone. The needle is now retracted very slightly and the syringe raised slightly towards the ventral surface of the patient, the point of the needle being thereby depressed. If the needle be now again pushed onwards it will pass, still guided by the finger in the rectum, along

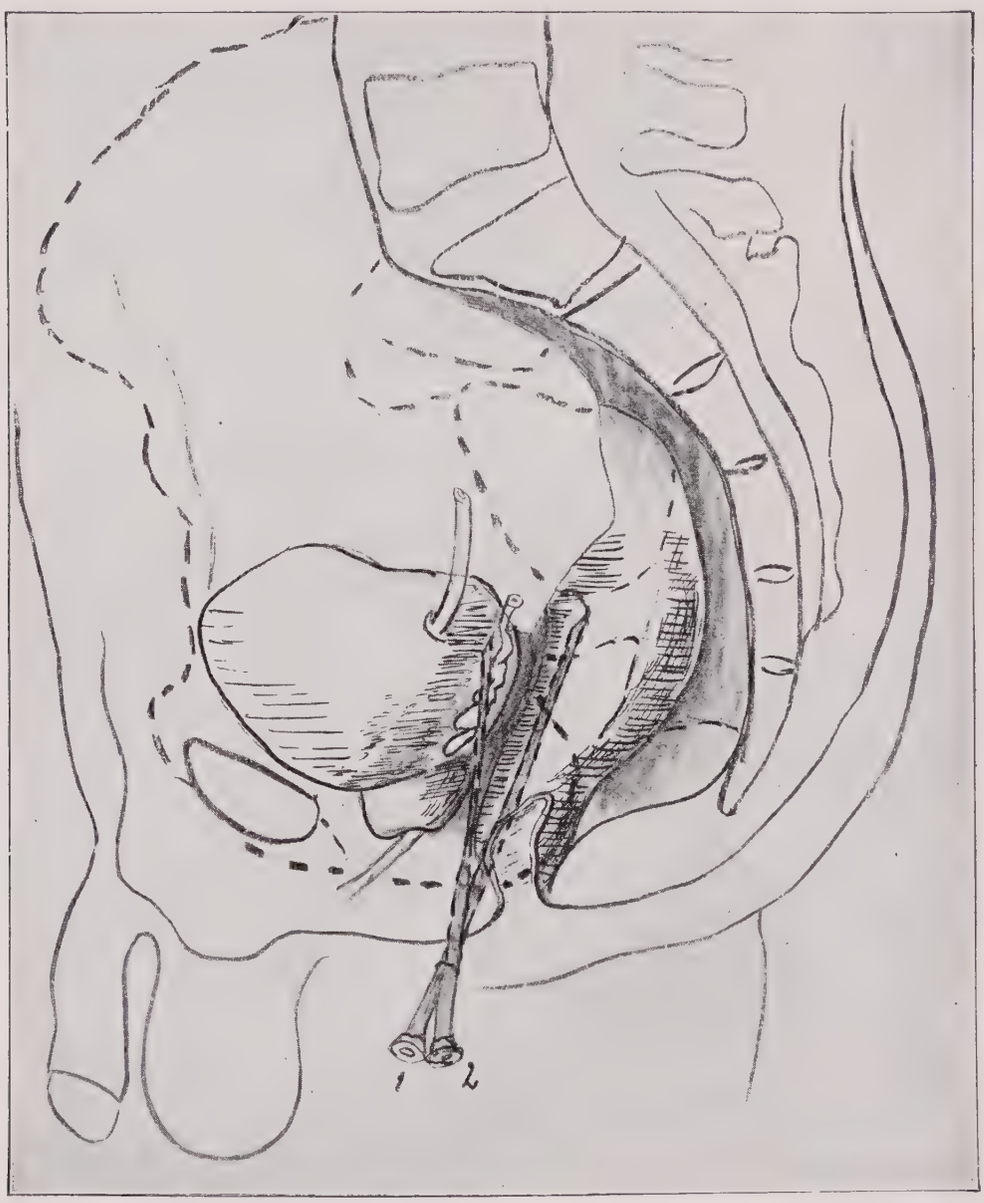

FIG. 73.—Position of needle for anæsthetization of prostate, according to Franke, Posner.

the dorsal side of the spine. It should now be pushed onward 1 to 2 cm. further, and 10 to 15 c.c. novocain solution should be injected, which will reach the pudic nerve.

The next step is to anæsthetize the pelvic nerve in the pelvic tissues behind the prostate. For this purpose the needle is again slightly retracted until only 2 to 3 cm. of it remain in the body; and again, under guidance of the rectal finger, it is pushed upwards along the anterior surface of the rectum, constantly injecting small qua ntities

of the anæsthetic as one proceeds, until the needle finally penetrates between the rectum and the prostate. If the prostate itself be struck this is noticed as a greater feeling of resistance, and the direction can be changed. The finger can reach up to this point; one then pushes the needle onwards in the same direction for another 3 to 4 cm., injecting the anæsthetic forcibly as one proceeds, and deposits several cubic centimetres more of the solution at this spot.

The same procedure is repeated on the other side, the hands being changed. Fig. 73 shows the positions of the needle behind the spine of the ischium (1) and between the rectum and bladder (2).

Finally, the above-mentioned twigs of the N. cutaneus femoris posterior (small sciatic) are anæsthetized by subcutaneously injecting for a distance of 7 to 10 cm. from behind forwards parallel to the middle line along the surface of the ischial tuberosity on both sides. The injections are best carried out with the patient in the lithotomy position.

Anæsthesia usually supervenes in from ten to fifteen minutes. In all about 7 grm. of novocain are required for the injection.

The technique above described is certainly rather complicated, and needs a considerable amount of practice, but, if correctly performed, excellent results are obtained.

Local Anæsthesia in Operations on the Anus and Rectum.

The anus lends itself particularly well to local anæsthesia. By its means the relatively insignificant but all the more painful affections which so often have their site at the anus can be operated on without any general anæsthetic being administered. Reclus and Schleich have repeatedly drawn attention to this fact.

The method described by Reclus, and consisting in the circum-injection of the anus in cases of operations for piles, is in principle that which is still followed; although the toxic cocaine at that time employed has been replaced by non-toxic novocain.

Whereas Reclus, having first anæsthetized the mucous membrane by cotton-wool plugs soaked in 1 per cent. cocaine, injected 0·5 per cent. cocaine solution into the skin and subcutaneous tissue at the margin of the mucous membrane round about the anus, Schleich, in the case of hæmorrhoidal operations, injected 0·1 to 0·2 per cent. solution of cocaine into the hæmorrhoids themselves, and then removed them.

For **hæmorrhoidal operations** Braun gives the following method:

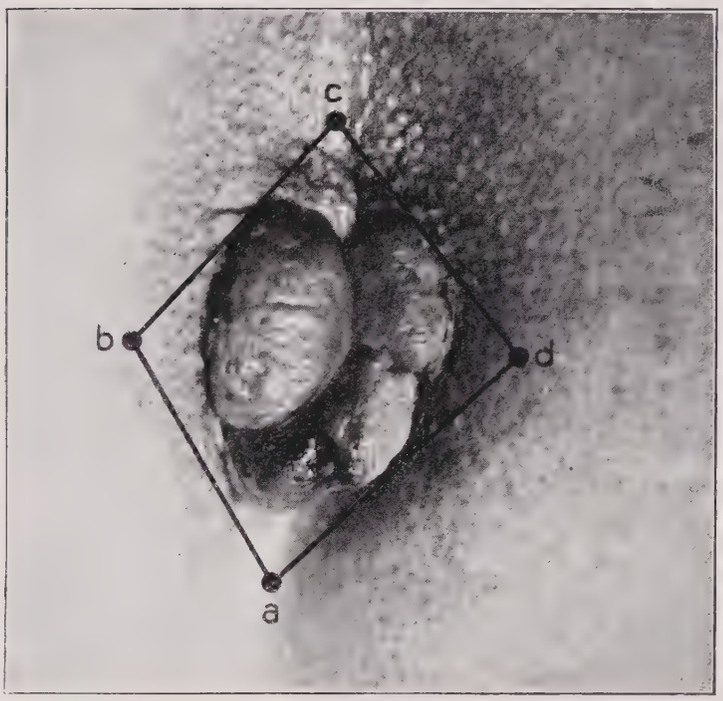

FIG. 74.—Anæsthetizing for hæmorrhoidal operations.

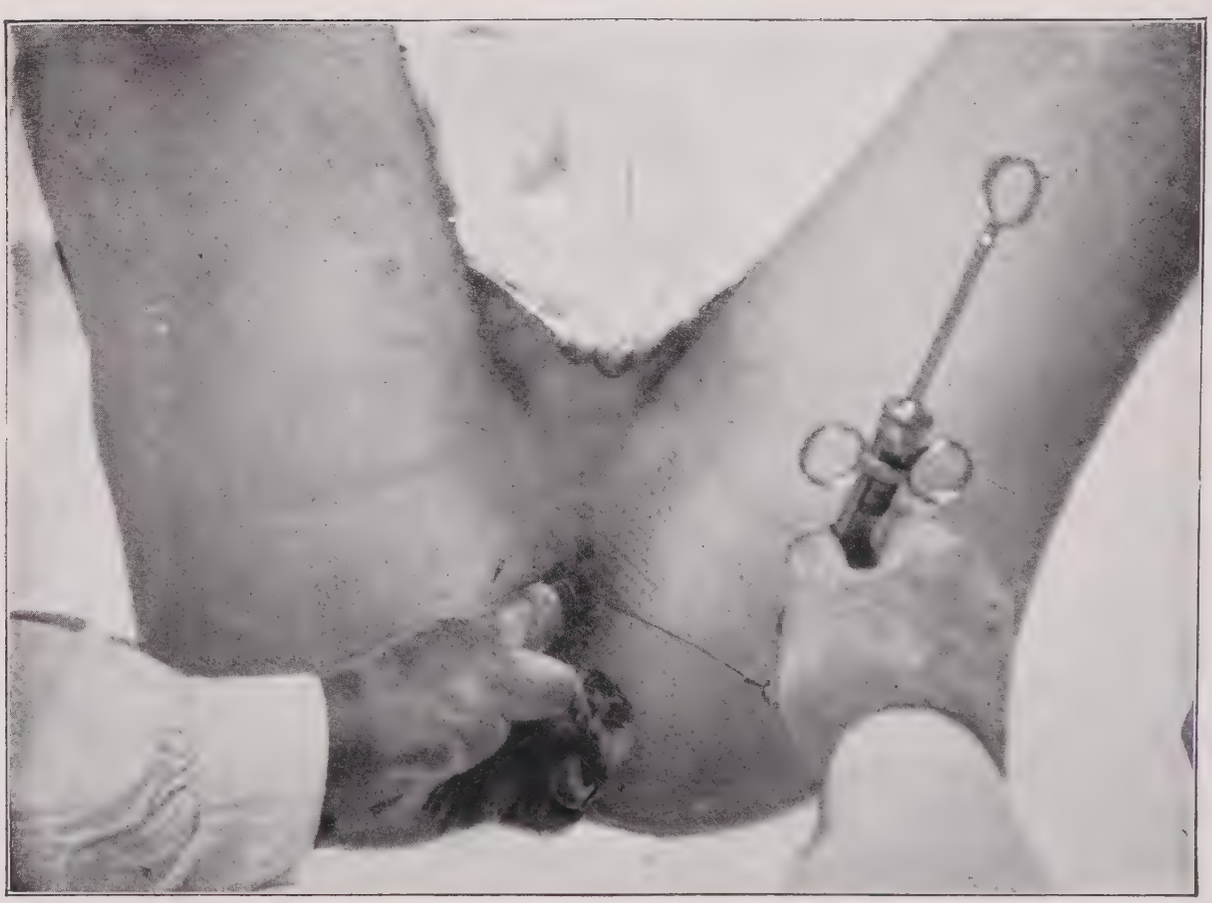

FIG. 75.—Anæsthetizing for hæmorrhoidal operations.

In the anal region, one finger's breadth from the margin of the mucous membrane, four infiltration wheals are marked in the skin (fig. 74, *a*, *b*, *c*, *d*). These points are then united by subcutaneous injections around the anus. The left index finger is now introduced into the anus. One now introduces the needle at the point *a*, and, infiltrating as one proceeds, guides the needle through the sphincter until one feels the point under the mucous membrane just above the anal ring. Again the needle is retracted and pushed onwards in a like manner in two other directions. The same procedure is repeated at points *b*, *c*, *d*.

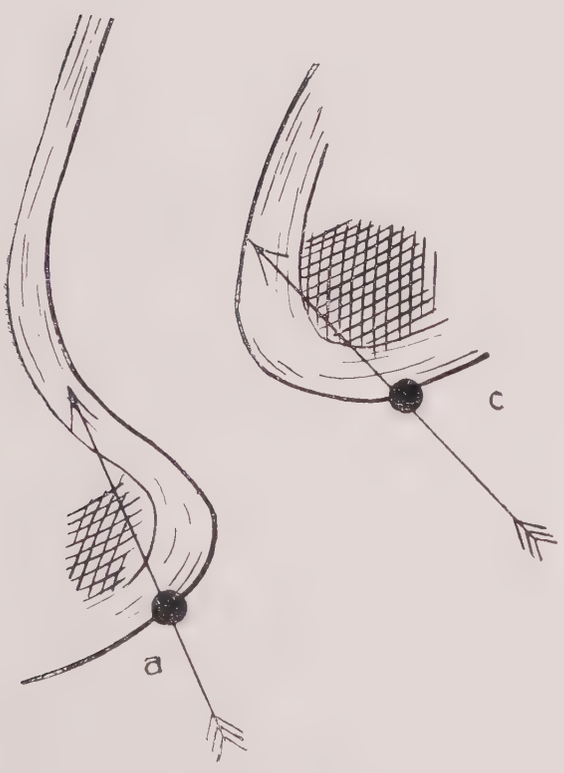

Fig. 76.

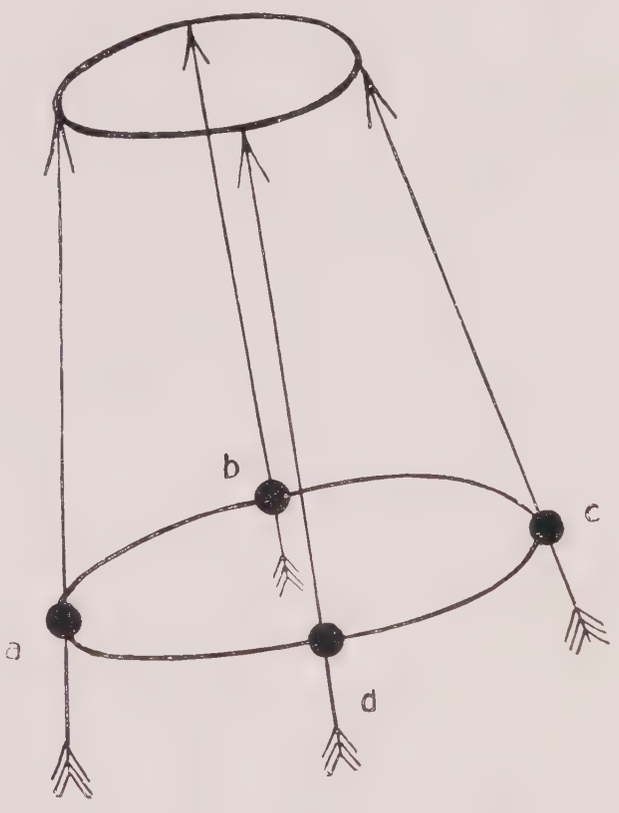

Fig. 77.

Fig. 76 represents a sagittal section showing the direction of the needle from two of the points. By means of these four series of injections the entire anal ring is infiltrated by the solution forming a layer of infiltration shaped like a truncated hollow cone. About 50 to 60 c.c. of 0·5 per cent. solution of novocain-suprarenin are necessary for the injection. The method can be highly recommended, being simple of performance and satisfactory in its results. It is certainly far preferable to the lumbar and extradural forms of anæsthesia on account of its greater simplicity and freedom from risk.

As the whole region is excessively sensitive, even the four original wheals have to be made with great care, and it is well to start with only one—the needle being pushed on subcutaneously to the site of the second—which can then be made from within outwards instead

of from without inwards. The needle is then withdrawn and re-introduced into the second wheal, which is now insensitive. The other wheals are made in a similar manner. Further, some care should be exercised in injecting steadily whilst pushing the needle onwards in the periproctic tissues. The whole technique requires patience and time. If these points are not carefully attended to, the induction of local anæsthesia in this region becomes torture to the patient.

By means of the method just described all hæmorrhoidal operations requiring distension of the anus can be performed absolutely painlessly. Smaller carcinomata and polypi that lie somewhat higher up the rectum can also be extirpated; only in this case it may be necessary to make the truncated hollow cone of anæsthetized area extend higher up the rectum, and this merely entails introducing the needle to a greater depth.

In the case of rectal fistulæ and fissures this form of anæsthesia is not required; it is sufficient to inject starting from two points external to the fistulous canal round the canal itself, having introduced a probe into the latter; the needle should be introduced up to the point in the rectal mucous membrane at which the fistula opens (or at which an opening will be forced). To facilitate the operation, it is well to introduce one finger into the rectum and use it to guide the point of the needle.

Extradural Anæsthesia.

By the term extradural anæsthesia is meant the injection of the anæsthetizing solution into the extradural space through the sacral canal. It is a conduction (regional) anæsthesia by which the conduction of a more or less extensive complex of sensory nerves mainly supplying the anal region and the genital organs is interrupted.

The nerves affected are the anococcygeal nerves and the nerves derived from the coccygeal plexus, viz., the pudic, the inferior hæmorrhoidal, the perineal and the dorsalis penis (clitoridis) nerves. Besides these, according to Laewen's experience, the visceral branches of the third and fourth sacral nerves, which are distributed as the middle hæmorrhoidal, the inferior vesical and vaginal nerves to the rectum, bladder and vagina respectively, are also interrupted.

Very often the N. clunium inferior medialis (inferior gluteal) and the N. cutaneus femoris posterior (small sciatic) are also interrupted.

The Nn. peroneus communis and tibialis (external and internal popliteal) are at times also touched by the anæsthetic, leading to paræsthesias and hypæsthesias of the legs and feet. As a rule isolated

nerve-trunks derived from all five segments of the sacrum are interrupted.

Some of the motor nerves are also affected ; and the paralysis of the sphincter ani is particularly useful in some surgical operations. Stoeckel draws attention to the flaccid condition of the floor of the pelvis after extradural anæsthesia.

The merit of having first drawn attention to this form of conduction-anæsthesia is due to the French surgeon Cathelin. In 1903 he published his experiments on sacral injection. He succeeded in producing anæsthesia of the whole body in a dog by injecting 3 c.c. of 1 per cent. solution of cocaine into the sacral canal ; in man the experiment was not successful. Attempts at inducing anæsthesia for hernia operations by injecting 0·01 to 0·08 cocaine hydrochloride in 1 and 2 per cent. solution into the sacral canal proved failures. Lejars, Tuffier, Reclus and Sicard also had no success. Chipault, on the other hand, succeeded in inducing anæsthesia in this manner on a few occasions.

Stoeckel was the first to employ the newer and relatively non-toxic preparations, eucaine and novocain, in epidural anæsthesia. He succeeded in producing considerable reduction in labour-pains by injecting 30 c.c. of 0·5 per cent. novocain solution. He called the method "sacral anæsthesia."

It was not till 1910 that Laewen succeeded in rendering the method practicable for surgical operations. He showed that only definite concentrations and definite quantities of novocain solution were of any use for producing this type of anæsthesia. These were 1·5 to 2 per cent. novocain solutions in volumes of 20 c.c. The fact discovered by Gros that the chlorides of the anæsthetic drugs combined with sodium bicarbonate acted more powerfully, was utilized by Laewen in his extradural anæsthesias ; he therefore added sodium bicarbonate to his novocain solutions. The solution was injected into the sacral region of the patient whilst in a sitting position. Anæsthesia set in after twenty minutes.

Later Schlimpert and Schneider injected larger doses of novocain and attempted to obtain anæsthesia up to a higher level by placing the patient with his pelvis raised. This was, however, only successful with the additional aid of larger quantities of narcotic drugs. On the evening preceding the operation the patient was given 1 grm. and on the morning of the operation 0·5 grm. of veronal, and one and a half hours before the operation 0·01 grm. of morphine and 0·0003 grm. of scopolamine. The same dose was repeated after three-quarters of an hour, except in the case of feeble patients. One of the conditions for the success of the anæsthesia was that this condition of semi-somnolence should be adequate. Schlimpert also tried narkophin as a narcotic.

Kroenig suggested that this so-called "**high extradural anæthesia**" should be used in younger women, whilst for cachectic women and such as were more than 60 years old as well as for patients with weak hearts, he preferred lumbar puncture.

The doses used by Schlimpert in obtaining high extradural anæsthesia varied between 0·4 and 0·8, the ordinary dose being 0·7, of a 1·5 per cent. solution of novocain-bicarbonate.

By means of these extradural anæsthesias induced in the high pelvic position, and with the additional aid of narcotics, it was possible to perform abdominal operations, such as Cæsarean section, and kidney and bladder operations. In a large proportion of the cases the anæsthesia proved inadequate, and the operation had to be continued under general anæsthesia.

In this high extradural anæsthesia, as practised by Kroenig, Schlimpert and Schneider, the local anæsthesia, as Laewen has emphasized, is completely driven into the background, as deep somnolence has to be induced by the administration of large doses of narcotics before anything like true anæsthesia is produced. It is generally recognized that extensive operations may not so very rarely be performed painlessly without the administration of any anæsthetic other than fair doses of morphine and scopolamine. Local anæsthesia is superfluous in such cases. It is to be hoped that in time it will be possible to obtain satisfactory anæsthesia by increasing the dose of our relatively non-toxic modern anæsthetics or by varying the technique somewhat without having to administer large quantities of narcotics. At present it seems very doubtful whether it would not be better to substitute local or general anæsthesia for these high extradural anæsthesias.

The **method of extradural anæsthesia** elaborated by **Laewen** renders it possible for us to perform painless operations on the anus, lower part of the rectum, perineum, urethra, penis and prostate (Wilms), also on the female genitalia (vulva and vagina). By it our field of local anæsthesia has been considerably enriched.

The author has often tested the method and seen excellent results, nevertheless he would be sorry to dispense with Braun's methods above described for anæsthetizing the anus in cases of hæmorrhoids, anal fistula, &c.; in fact he regards the latter method as at least as good.

Laewen recommends the following combination of powders containing respectively 2 and 1·5 per cent. novocain sodium bicarbonate for extradural anæsthesia.

(1)	Sodii bicarbonatis puriss. pro analysi Merck ...	0·15 grm.
	Sodii chloridi	0·1 ,,
	Novocaini	0·6 ,,

To be dissolved in 30 c.c. of distilled water.

This gives a 2 per cent. solution of novocain-sodium-bicarbonate, of which 20 c.c. should be injected.

(2) Sodii bicarbonatis puriss. pro analysi Merck ... 0·2 grm.
Sodii chloridi ... ... 0·2 ,,
Novocaini ... ... 0·75 ,,

To be dissolved in 50 c.c. of distilled water.

This gives a 1·5 per cent. solution of which 20 to 25 c.c. may be injected.

The powder should be dissolved in the distilled water in an Erlenmeyer flask. After the solution is complete the fluid is boiled up once. The boiling should not be continued any longer, as that would render the solution useless. The boiling not only sterilizes the fluid but increases its anæsthetizing power (Gros). The solution should now be cooled under a stream of water and 5 drops of 1 in 1,000 adrenalin solution should be added.

Wilms recommends the injection of 20 c.c. of salt solution before proceeding to the injection of the 2 per cent. novocain solution, the object being to limit the novocain absorption.

The technique of the procedure is as follows: It is best to employ a "Record" syringe having a long hollow needle, such as Bier recommends for lumbar anæsthesia. The syringe should be of 20 c.c. capacity, and should be boiled in salt solution before being used. Laewen recommends that the patient should be in a sitting posture, his object being to retain the anæsthetizing solution in the sacral canal as long as possible, so that it may act on the dural sheaths.

The point of introduction of the needle lies in the centre of an imaginary vertical line drawn from the apex of the sacral triangle to its base. The hiatus sacralis which is as a rule triangular in shape should be felt for, the small prominences at the base of the triangle, the sacral cornua, being sought for; the apex of the triangle is formed by the upper end of the sacral aperture. Many anatomical variations occur, so that it is often difficult or even impossible to reach the sacral canal with the needle. A considerable layer of adipose tissue is also frequently a complete impediment to the performance of extradural anæsthesia.

The sacral membrane is pierced by the needle, an infiltration wheal having first been raised at the point of insertion, if desired, in order that the pain caused by the introduction of the needle may be diminished. The needle is now gently and slowly insinuated along the sacral canal, being carefully guided along the curves of the latter. Having reached a depth of about 6 cm. the movement is stopped. The needle has now entered the canal for a distance of between 4 and 5 cm. The solution should now be injected slowly. Laewen lays great stress on this latter point; he takes two

or more minutes for the actual injection of the fluid. According to him, it tends to diminish the amount of the anæsthetic taken up into the blood-vessels, further the solution remains at the lower part of the epidural space and the injection can be stopped the moment any untoward general symptoms arise.

As a rule it takes about twenty minutes for the maximal anæsthesia to be attained. According to Laewen, the longest interval amounts to twenty-five, the shortest to ten minutes. The anæsthesia commences between the coccyx and the posterior border of the anus. From this point it spreads over the perinæum and the skin of the scrotum, to the penis and glans. The highest level is reached when the anæsthesia reaches the glans. Laewen also observed unilateral anæsthesia of the penis, the other side being still sensitive to pain. The anæsthesia extends upwards as far as the pubes and downwards well into the gluteal region. The urethra, vulva, vagina and the cervical portion are also rendered anæsthetic. Sometimes the prostate is also anæsthetized. The testicles, being innervated from a higher segment, remain sensitive.

Schlimpert and Schneider observed an extension of the anæsthesia to the navel, sometimes to the breast or to the lower border of the second rib, when using the high pelvic position. The duration of the anæsthesia is, according to Laewen, one and a half to two hours, but it is very variable and hence unreliable.

The concomitant symptoms of extradural anæsthesia are not very severe as a rule, provided the method of injection be correctly carried out and the solutions used be not too concentrated. They consist of acceleration of the pulse, giddiness, vomiting, and perhaps even collapse. Should a vein in the sacral canal be injected with novocain solution respiratory disturbances may supervene, necessitating artificial respiration (Kroenig).

Strauss has reported a case of death during the performance of high extradural anæsthesia. The patient, a woman aged 27, had been given 0·04 grm. of pantopon and 0·0006 grm. of scopolamine, and 0·6 grm. of novocain had been injected in 50 c.c. of solution. Laewen thinks that possibly the high dose of novocain had acted toxically. The more obvious explanation would be that the summation of large doses of the drugs administered should be made responsible for the fatal result.

Bleek gives a warning against the use of very high extradural anæsthesia on account of the large amount of novocain required.

Laewen regards the administration of more than 0·4 grm. of novocain into the epidural cavity as risky.

The author has himself observed slight collapse in several cases, and severe collapse in one case when injecting the doses of novocain recommended by Laewen in the correct manner. No other untoward symptoms were observed.

Local Anæsthesia in Operations on the Upper Limb.

The hand, and especially the fingers, formed a good and profitable field for the application of local anæsthesia. This was, therefore, applied for the purpose at a very early stage of its evolution. At the period of cocaine anæsthesia this toxic anæsthetic could be used with impunity and with success in the case of the fingers, since only relatively small quantities of the drug were required to infiltrate and anæsthetize the lesser diameter of a finger (Oberst's method).

Even larger nerves were attacked; Crile exposed these and applied endoneural injections. The method was not well received; it was cumbersome and unpleasant for the patient.

Braun injected the median nerve (medial cutaneous) perineurally. The point of introduction of the needle was three finger-breadths above the pisiform bone. He also reached the ulnar three finger-breadths above the wrist, introducing the needle on the ulnar side of the forearm between the ulna and the tendon of the flexor ulnaris muscle through the skin and under the fascia for a distance of 1·5 to 2 cm., and injected there.

The radial nerve (musculospiral), that is to say its terminal branches, was injected subcutaneously by Braun in the transverse plane above the styloid process, past this and into the middle of the extensor side of the wrist. By combining this anæsthesia with that of the median nerve, Braun succeeded in inducing anæsthesia of the radial half of the hand.

Krogius struck the ulnar nerve at the internal condyle of the humerus; it was even possible to make an endoneural injection at this point. When operating on the forearm subcutaneous circumscribing injections were used in addition to these injections into the nerve-trunks. Reclus, Schleich, Ried and Matas reported cases of amputations of the forearm under this form of anæsthesia.

Operations of the upper arm were more rarely undertaken under local anæsthesia; as a rule, these were restricted to operations on the skin, skin grafting operations according to Thiersch's method, the skin being taken from the arm, &c. Reclus described one amputation of the upper arm. Crile exposed the brachial plexus at the posterior border of the sterno-cleido-mastoid and injected small quantities of 0·5 per cent. solution of cocaine into each main trunk. Under this anæsthesia he was able to perform exarticulation of the shoulder-joint. Oberst's method of injecting the fingers is still largely used, as is also Braun's perineural injection, especially for anæsthetizing

isolated portions of the hand. Crile's method of exposing the brachial plexus will hardly have found any adherents.

Further, Manz's experiments carried out in 1898, relating to anæsthetizing the plexus, are noteworthy. Having constricted the arm, he injected 0·5 per cent. solution of cocaine into the bicipital groove, and thereby attained partial anæsthesia of the arm. The procedure was only applied in a few isolated cases, and was never elaborated into a definite method.

It is only recently that it has become possible to reach the brachial plexus percutaneously with the needle and to anæsthetize it sufficiently to render the entire arm insensitive. This has been one of the great advances made in local anæsthesia. A large number of cases have thereby been removed from the realm of general anæsthesia.

Hirschel, as the result of the experiences he had gained in anæsthetizing the axilla for the purpose of removing its contents in mammary carcinoma, and in which he for the first time came into intimate contact with the brachial plexus, attempted to extend this method of anæsthetizing the plexus to operations on the arm. The quantity of novocain used in anæsthetizing for operations on mammary carcinoma was relatively high as compared to the doses usually employed, and it nevertheless appeared that no symptoms of intoxication supervened even when the percentage concentration of the novocain was increased still further. We now know that 1 grm. of novocain may be administered by injection without risk. Taking advantage of this relative non-toxicity of novocain, the author has used considerable quantities of 2 per cent. solution (30 to 40 c.c.) when anæsthetizing the brachial plexus. The 1 per cent. concentration employed for local anæsthesia in the case of mammary carcinoma for the removal of the axillary contents was too weak to induce anæsthesia of the whole arm. Whilst the plexus itself became quite insensitive, so that the tissues could be dissected off the nerves, it was only possible to induce strips of hypæsthesia in the upper arm, and the forearm retained its sensitiveness unimpaired. By using the above-mentioned 2 per cent. solution of novocain-suprarenin in quantities amounting to 30 to 40 c.c., it was possible to induce anæsthesia of the entire arm within ten to twenty minutes.

In order to attain more rapid permeation of the solution into the nerve-trunks, that is, to prevent the too rapid absorption of the anæsthetic, Hirschel, in his first experiments on plexus anæsthesia, applied a pad in the axilla above the point of injection thereby producing venous stasis in the arm. The greater the stasis produced, the quicker and the more certain was the anæsthesia obtained. This method of retarding absorption by producing venous stasis became known as the results of experiments by Klapps. Later Hirschel gave up using his compressing band, and the results were just as satis-

factory. In a few cases the anæsthesia only extended as far as the middle phalanges.

Soon after Hirschel had published his experiences on brachial plexus anæsthesia, Kulenkampff reported his experiments in the same field of research. He had succeeded in interrupting the conduction of the brachial plexus in the supraclavicular fossa, where it passes over the first rib. He performed the first experiment on him-

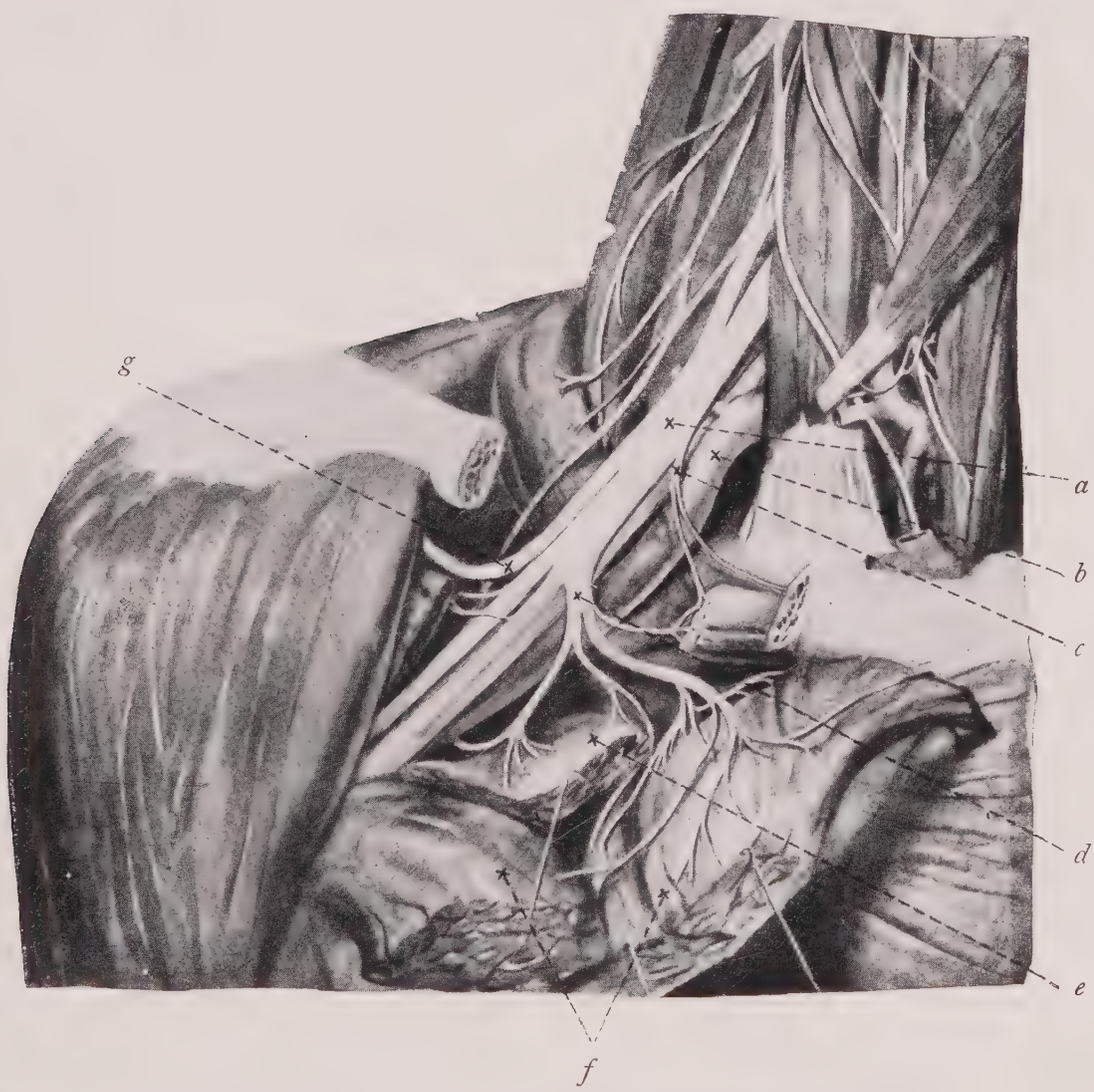

FIG. 78.—(After Spalteholz). *a*, Plexus brachialis (pars supraclavicularis). *b*, Art. subclavia. *c*, N. subclavius. *d*, Nn. thoracales anteriores. *e*, M. pectoralis minor. *f*, M. pectoralis major. *g*, N. suprascapularis.

self, and found that severe paresis of the whole arm, accompanied by anæsthesia and hypæsthesia, followed an injection of 5 c.c. of 2 per cent. solution of novocain. He then made further experiments with 10 per cent. solutions on patients, and obtained successful results. The point selected by Kulenkampff is most favourable, inasmuch as a bony guide for the direction of the needle is provided by the first rib.

Fig. 78 shows the brachial plexus crossing the first rib, the clavicle

having been removed. The subclavian artery lies medially, the brachial plexus, still united as a single bundle, lies laterally.

According to Kulenkampff's method the plexus is injected endoneurally, provided the correct point for the injection be struck. There is perhaps one drawback to the method in that the technique is not quite as simple as it might seem to be. Injuries to the subclavian artery seem to be of no import. On the other hand, unpleasant consequences due to injuries to the pleura and lung may occur. Heile reports a case of plexus anæsthesia according to Kulenkampff's method, in which the pleura was injured by the needle, leading to subsequent pleurisy, which, however, passed off satisfactorily.

Unfortunately not all the nerves innervating the arm are anæsthetized by this method. The N. cutaneus brachialis medialis (lesser internal cutaneous) which receives branches from the intercostal nerves as the N. intercosto-brachialis (intercosto-humeral), and supplies the sensory innervation to the inner side of the upper arm, is unfortunately not interrupted in its conduction (fig. 53). Kulenkampff therefore suggests that when operating high up in the upper arm, the latter should be circumscribed by subcutaneous injections as well.

The employment of plexus anæsthesia is particularly indicated where operations on the hand, forearm, elbow, and upper arm are in question. For finger operations Oberst's method is to be preferred. In the first place it is simpler, and, secondly, anæsthesia is more rapidly induced by it than by the plexus method. Further, it must be remembered that plexus anæsthesia sometimes fails to reach the fingers. It is therefore far better to employ the generally adopted and very excellent method of Oberst for finger operations.

For minor surgical operations in the middle of the hand the methods of procedure suggested by Braun would seem to be more suitable for many cases. The latter author has given us various methods for inducing anæsthesia applicable to the individual regions of the hand, all of which are of value, and shall be described later.

The Nerves of the Arm.

For anæsthetizing the brachial plexus an exact knowledge of its anatomical relations is essential. The root complex of the plexus is situated between the anterior and the middle scalene muscles, the three upper roots being above, the two lower behind the subclavian artery. The plexus narrows down and runs along with, and laterally to the artery behind the clavicle and the sub-clavius and pectorales muscles towards the axilla. The plexus is sub-divided into a supra-clavicular and an infra-clavicular portion. The former lies

on the middle scalene muscle, is pierced by the arteria transversa colli (transverse cervical), and is crossed by the omohyoid muscle. Its main branches are the posterior and anterior thoracic nerves and the N. axillaris (circumflex nerve). The latter arises in the axilla from the posterior fasciculus of the infra-clavicular part, and runs backwards behind the axillary artery through the gap between the humerus and

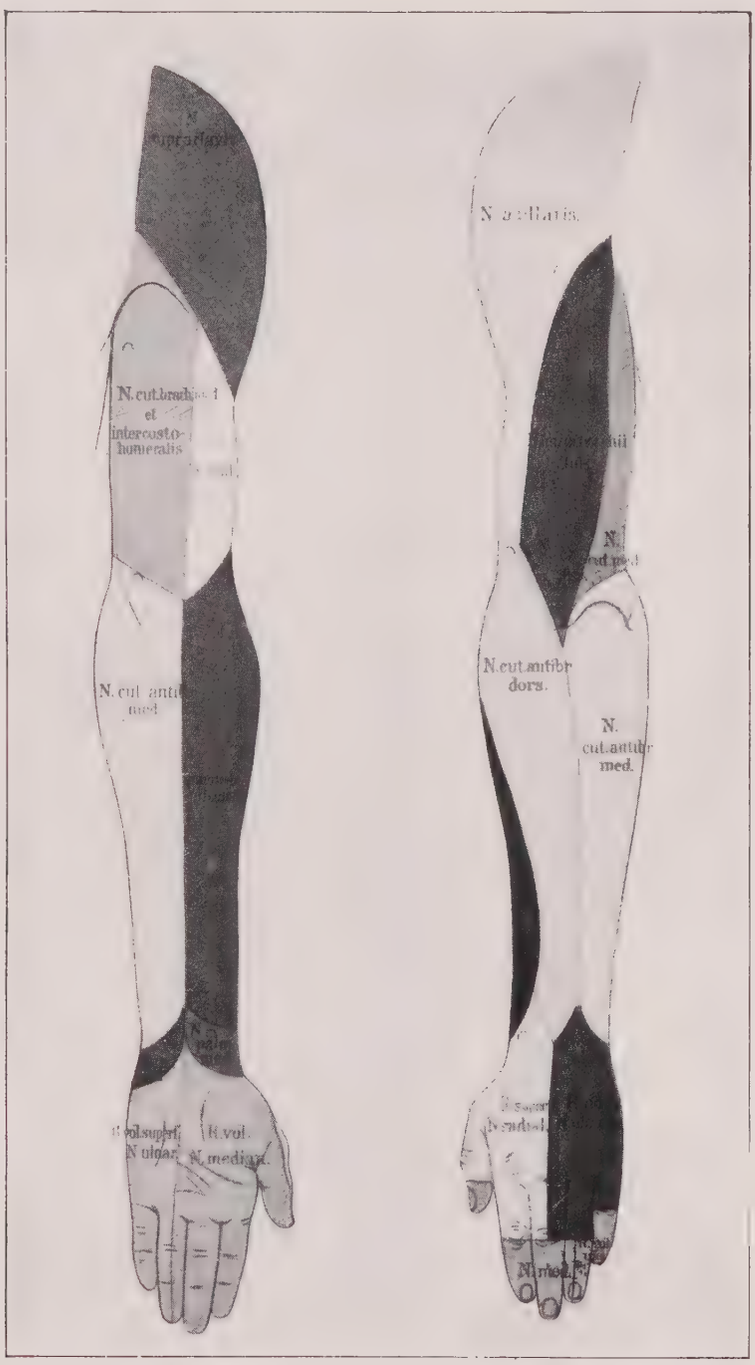

FIG. 79.—(After Hasse.)

the teres minor and major muscles and the long head of the triceps, and then laterally on the surgical neck of the humerus. It is covered by the deltoid muscle. Its terminal branch, the N. cutaneus brachii lateralis (cutaneous branch of the circumflex), runs between the deltoid

muscle and the long head of the triceps to the skin of the posterior and lateral part of the upper arm (fig. 79).

The infra-clavicular portion of the brachial plexus traverses the axilla and is divided into three main trunks, which are related to the axillary artery as follows: the fasciculus posterior runs dorsally, the fasciculus lateralis laterally and above, and the fasciculus anterior medially and below the artery.

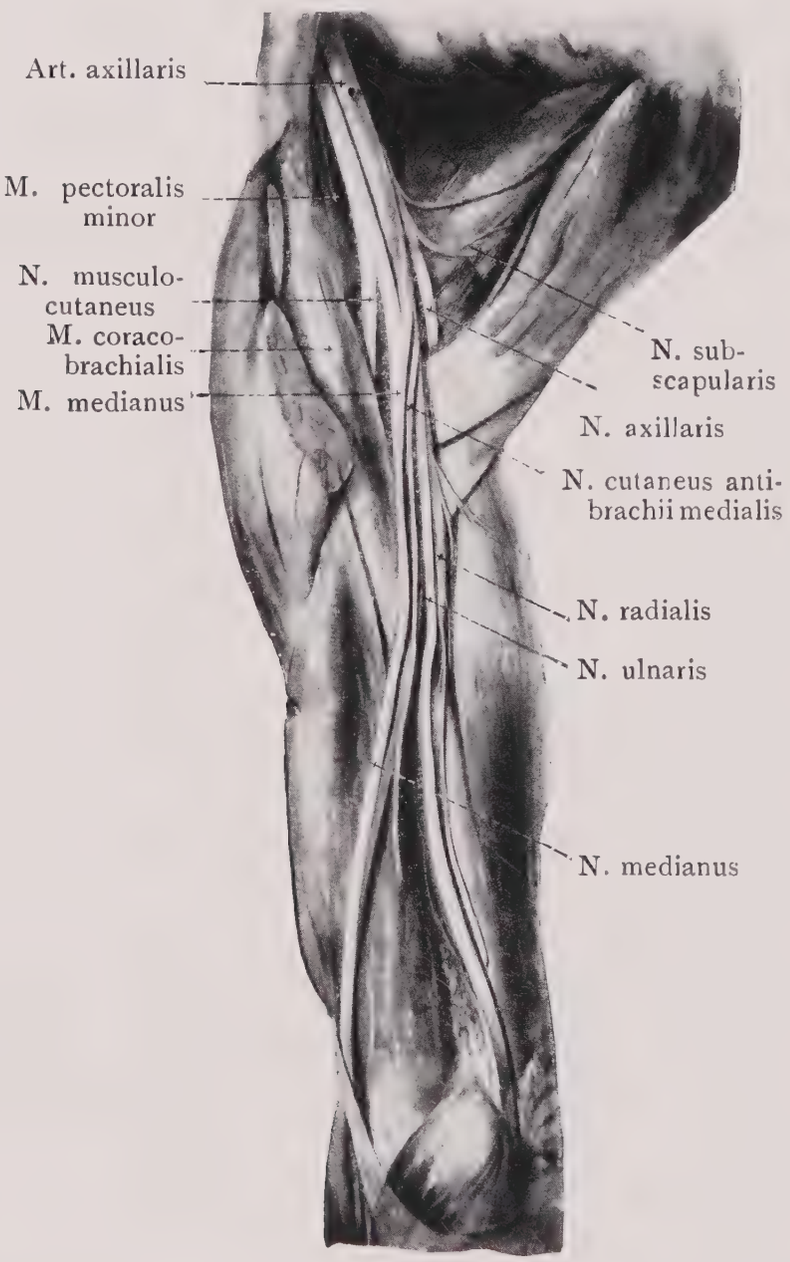

FIG. 80.—(After Spalteholz.)

From the medial fasciculus arises the Nn. cutaneus brachialis medialis (lesser internal cutaneous), cutaneus antibrachii medialis (cutaneous branch of the musculo-cutaneous), ulnaris and the lower root of the median nerve. From the lateral fasciculus arise the upper root of the median nerve and the musculo-cutaneous nerve, and from

the posterior fasciculus arise the Nn. axillaris (circumflex) and radial (musculospiral) nerves (*cf.* fig. 80).

The important cutaneous nerves are :—

(1) N. cutaneus brachii medialis (lesser internal cutaneous nerve) unites in the axilla with the N. intercosto-brachialis (intercosto-humeral) of the second and sometimes also the third intercostal nerves (figs. 53, 79). Its branches supply the skin of the axilla and the medial surface of the upper arm as far as the elbow, and in addition a part of its proximal and anterior surface, and of its distal and posterior surface.

(2) The N. cutaneus antibrachii medialis (internal cutaneous) pierces the brachial fascia at the middle of the upper arm where the median basilic vein disappears under the fascia, and divides into the ramus volaris (anterior) and ramus ulnaris (posterior branch); the former is distributed to the ulnar half of the anterior surface of the forearm down as far as the ball of the little finger; the latter supplies the skin of the ulnar half of the dorsal surface of the forearm (fig. 79).

(3) The N. musculo-cutaneus at first runs laterally and dorsally to the median nerve and the axillary artery (fig. 80), and pierces the coracobrachialis muscle. Its terminal branch is the N. cutaneus antibrachii lateralis (cutaneous branch of the musculo-cutaneous nerve), which supplies the skin of the radial border and the radial half of the volar surface of the forearm, of the ball of the thumb and of the radial part of the dorsum of the hand.

The course and area of distribution of the three great main branches, the N. medianus, radialis and ulnaris, is briefly as follows :—

(1) Nervus medianus runs together with the brachial artery along the dorsal surface of the coracobrachialis muscle, then along the bicipital groove and enters the deep tissues of the bend of the elbow beneath the lacertus fibrosus (membranous band of the insertion of the biceps). Here it sends a few sensory twigs to the capsule of the elbow-joint. Having given off branches to the muscles of the forearm it terminates as the ramus cutaneus palmaris on the skin of the ball of the thumb and palm, and as the Nn. digitalis volares communes. The sensory areas supplied are represented in fig. 79.

(2) The N. ulnaris at first runs along the posterior medial side of the axillary and brachial arteries (fig. 79) in front of the radial (musculospiral) nerve, later it runs along the anterior medial surface of the medial (inner) head of the triceps behind the medial (internal) intermuscular septum downwards towards the ulnar groove of the humerus; it is covered during this part of its course only by brachial fascia. In the groove it lies between the epicondylus medialis (internal condyle) of the humerus and the olecranon process of the ulna directly on the bone, and is easily reached at this point by the needle. About the middle of the forearm it divides into its two terminal branches, the ramus dorsalis manus, and the ramus volaris manus

(figs. 81, 82). In the forearm it anastomoses with the median nerve and sends off muscular branches as well as a ramus cutaneus palmaris which arises in the middle of the forearm, accompanies the ulnar artery as far as the skin, and furnishes a branch to the volar surface of the wrist and ball of the little finger.

FIG. 81.—(After Spalteholz.)

The ramus dorsalis manus (fig. 82), the weaker of the two branches, runs along the ulna, between it and the tendon of the flexor carpi ulnaris to the dorsal surface of the head of the ulna. Here it pierces the fascia and divides over the dorsal carpal ligament. The sensory distribution is shown on fig. 79.

The ramus volaris manus, the second terminal branch, runs along the ulnar side of the ulnar artery and the border of the flexor carpi ulnaris between the latter and the flexor digitorum sublimis covered

only by the fascia, towards the hand, where it divides before reaching the lig. carpi transversum into a superficial and a deep branch.

(3) The N. radialis (musculospiral nerve) arises from the posterior part of the plexus and runs behind the brachial artery together with the deep brachial artery and vein to the posterior aspect of the upper arm. It is contained in the spiral groove of the humerus

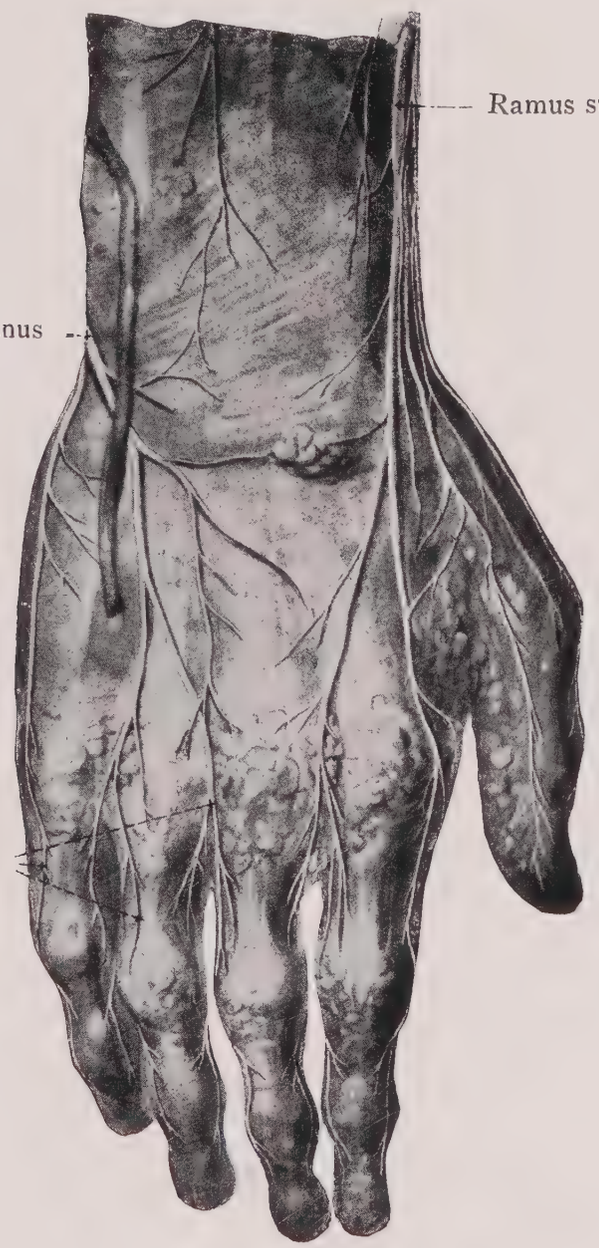

FIG. 82.—(After Spalteholz).

covered by the triceps muscle. In thin subjects it may be felt at the lateral (external) border of the triceps. It then reaches the anterior surface of the arm between the brachial and the brachio-radialis (brachialis anticus and supinator longus) muscles. In front of the head of the radius it divides into a deep and a superficial branch.

As a sensory nerve it supplies the skin of the extensor surface of

the upper arm by the N. cutaneus brachii post. (internal cutaneous branch of the musculospiral nerve), and the skin of the forearm as the N. cutaneus antibrachii dorsalis (external cutaneous branch of the musculospiral) (fig. 79). The terminal branch reaches the dorsal surface of the hand as the ramus superficialis (radial nerve) and supplies its radial side.

Anæsthetizing the Brachia Plexus. (Hirschel, Kulenkampff).

The indications for anæsthetizing the entire brachial plexus have already been discussed, and it was then emphasized that for operations on the fingers the well-tried method of Oberst was to be preferred on account of its simplicity. In the cases of minor and not complicated operations in the hand there is the choice between anæsthetizing the entire plexus or inducing infiltration-anæsthesia of individual segments of the hand according to the methods suggested by Braun. For operations on the upper arm, elbow and forearm, plexus anæsthesia should be employed.

The technique of axillary plexus anæsthesia as elaborated by Hirschel is as follows: The patient lies extended on the table; the arm that is to be anæsthetized is held upwards but not to its maximal extent (fig. 83). With the left hand the pulsating brachial artery is felt for, with the right the syringe is held in the direction of the arm with the point towards the axilla. The needle is introduced into the skin over the arteries injecting as it is advanced. The best point to introduce the needle is near the insertion of the latissimus dorsi (*cf.* fig. 80). After about 10 c.c. of 2 per cent. novocain-suprarenin solution have been injected over the artery for a distance of 3 to 4 cm., the needle is retracted, but not completely, and the same amount of solution is introduced laterally and medially to the artery. Whilst doing so the artery may be held aside a little by the left hand. In front and above the ulnar and the median nerves are struck; for the injection of the N. radialis (musculospiral nerve) the needle must be pushed under the artery, as the nerve passes in this situation. The point of insertion of the needle is shown in fig. 80. Finally, the needle should be pushed upwards towards the first rib as far as possible under the pectoralis muscle, in order that the musculocutaneous nerve may be struck. The axillary (circumflex) nerve is reached at the same level but below the artery (fig. 80). At each of the two points about 10 c.c. of the solution are deposited. In all about 40 to 50 c.c. of solution are used, sometimes 30 c.c. will suffice; should anæsthesia be long delayed, a further 20 c.c. can be injected subsequently.

Frequently the nerves themselves are directly touched by the

needle, the fact being manifested in the form of paresis of the corresponding part of the arm; in such cases anæsthesia of the fingers may supervene already after three to four minutes, and will be noticed gradually to extend down the arm to the forearm and hand.

In obese patients anæsthesia does not always supervene immediately. On an average it takes ten minutes for the entire arm to become insensitive, and yet sometimes it may take as much as thirty minutes. Cases of complete failure also occur, as well as cases in which the anæsthesia only reaches to the phalanges.

FIG. 83.—Position of syringe for axillary anæsthetizing of the brachial plexus, according to Hirschel's method.

As a rule excellent anæsthesia is obtained for operations on the upper arm, the elbow and forearm, as well as the hand (amputations, resections, tendon sutures, cellulitis, &c.).

Injuries to the blood-vessels have not been met with, at least they gave no symptoms. It is advisable to continue injecting as the needle advances. If necessary one can ascertain whether blood flows after the needle has been introduced, and thus control whether one has entered the vessels; this precaution is, however, not really necessary.

The needles used for plexus anæsthesia are the same long fine needles that have been described above. Anæsthesia usually persists for one and a half hours.

The **technique for the supra-clavicular plexus anæsthesia** is as follows: With the patient in a sitting posture the subclavian artery is felt for. An infiltration wheal is made externally over the point where the artery disappears downwards behind the clavicle (fig. 84).

FIG. 84.—Introduction of the needle in supra-clavicular anæsthetizing of the brachial plexus according to Kulenkampff's method.

This lies in the centre of the clavicle. The position of the omohyoid is clearly defined if the patient swallows, so that it need not be pierced. By firm pressure with the finger in the direction of the spinous processes of the upper dorsal vertebræ the nerve-trunks may sometimes be rolled against the first rib under the finger.

A 6 cm. long needle is introduced and slowly pushed towards the first rib. The direction of the needle points towards the spine

of the second to the third dorsal vertebra. The rib is reached at a depth of 0·5 to 1·3 cm. The plexus lies between the skin and the rib. As a guide to the distance reached by the needle Kulenkampff uses a small piece of cork through which the needle is pierced, and which can then be moved up and down the needle as required. Using the needle one palpates the deep tissues until one finds the nerves, the fact being indicated by paræsthesias in the arm. If the plexus be not encountered at once it should be cautiously searched for until the typical paræsthetic symptoms are produced. If the point of the needle pierces the nerve-sheath tingling in the hand and tips of the fingers occurs. The needle is then kept in this correct

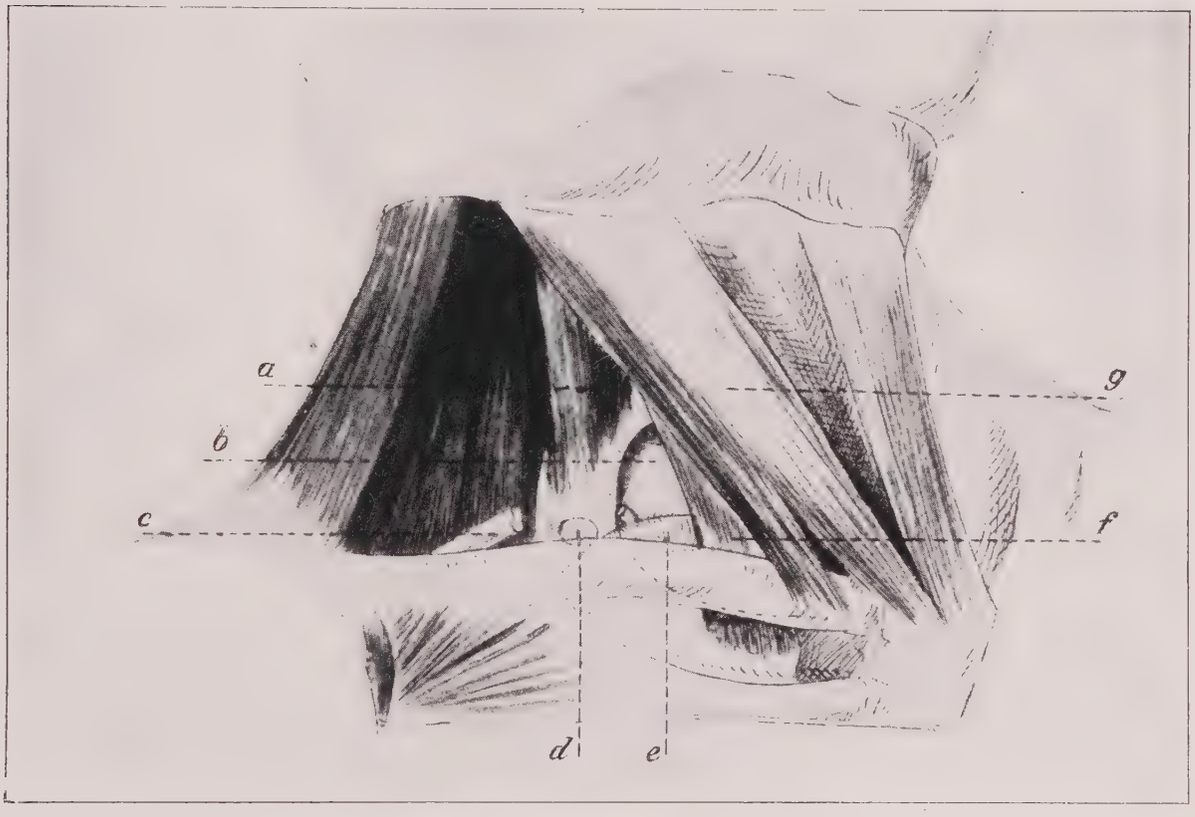

FIG. 85.—(After Kulenkampff.)

position and the syringe connected with it. During the actual injection the paræsthesia is increased. The injection is performed endoneurally.

Kulenkampff uses about 20 c.c. of 2 per cent. solution of novocain-suprarenin which he prepares from the tablets. Fig. 85 is taken from Kulenkampff's work and clearly shows the anatomical relations of the plexus and the point of injection : *a* is the middle scalene, *b* the apex of the lung, *c* the omohyoid, *d* the cutaneous infiltration wheal, *e* the subclavian and the tranverse cervical arteries, *f* the anterior scalene muscle, and *g* the sterno-cleido-mastoid muscle.

Kulenkampff reports that on several occasions whilst searching for the plexus a few drops of blood appeared from the cannula. It

was clear that the subclavian artery might have been injured, but there were no ill-consequences. According as the paræsthesias are marked or mild the anæsthesia may be rapid or delayed. After marked paræsthesia it supervenes rapidly, sometimes already after one to three minutes. Sometimes, however, half an hour may elapse before the anæsthesia appears. The average duration of the anæsthesia is one and a half to two hours.

The sensory paresis does not include the entire upper arm, the upper third retains normal sensation. Kulenkampff, therefore, suggests that in cases in which the upper third of the arm has to be operated on, circumscription of the arm by subcutaneous injection should be added. With this method also cases of complete failure have occurred, and the injection may have to be repeated. Kulenkampff therefore recommends that if no complete action of the anæsthetic has supervened after ten minutes, a second injection of 5 to 10 c.c. of 4 per cent. novocain-suprarenin solution should be made. When injecting the plexus one may meet with several difficulties; on the one hand, the pulsation of the subclavian artery may be difficult to feel; this may be obviated by increasing the heart's action by making the patient do a double knee-bend several times. Or again, a thick layer of fat over the supra-clavicular hollow may be in the way; if this is the case the needle may have to be introduced to a considerable depth before it meets the rib. On one occasion Kulenkampff had to introduce the needle a distance of 7 cm. in a very stout patient.

Injuries to the pleura and lungs are of course possible. Kulenkampff himself has not met with a case, but we have already mentioned such a case reported by Heile, in which pleurisy occurred after injury to the pleura.

Kulenkampff recommends his method of plexus anæsthesia apart from operations on the arm, also for the reduction of dislocations of the shoulder. According to him even old-standing dislocations can be reduced with ease under this form of anæsthesia. He employs a modification of Riedel's method for reduction, in which, without any jerk, the arm is drawn by a steady pull towards the spine of the opposite scapula.

Another method for anæsthetizing in the case of **dislocations of the shoulder**, elbow, thumb and also, as we shall see later, of the hip, is recommended by Quénu. The anæsthetic is injected from several sides towards the proximal and the luxated end of the joint; in dislocations of the shoulder from the side through the deltoid into the glenoid cavity, and from in front into the head of the humerus. The injections into the attachments of the muscles, which Quénu suggests, are considered superfluous by Braun. The latter uses 20 to 30 c.c. of 1 per cent. solution of novocain-suprarenin for anæsthetizing in the case of shoulder dislocations.

In the same manner **fractures** may be anæsthetized for the purpose of setting. Lerda and Quénu, using the strictest aseptic precautions, inject the anæsthetizing solution from one or more points towards the fractured ends, so that the solution may come into intimate contact with the fragments and the periosteum. If two bones be fractured both must be correspondingly anæsthetized. In the case of fractures into a joint the solution must be injected into the joint. Lerda and Quénu employ 0·5 per cent. solution of cocaine with adrenalin added. Novocain in 1 to 2 per cent. solutions might be suggested as a substitute for cocaine.

To anæsthetize the field for **v. Langenbeck's operation of resection of the shoulder-joint** Hohmeier recommends the following method : The nerves, the conduction of which has to be interrupted, are the N. axillaris (circumflex) and the N. supra-scapularis as well as the supra-clavicular nerves (including the supra-acromial).

The N. axillaris Hohmeier anæsthetizes by circum-injecting the brachial plexus in the axilla (Hirschel's method). Having abducted the arm horizontally he determines the position of the artery ; fixes it with the fingers of the left hand and presses it downwards. A slightly curved needle, without the syringe, is now guided round the artery and pushed upwards as far as possible (*cf.* fig. 80). If no blood flows from the cannula, the solution (0·5 per cent. novocain-suprarenin) is injected.

To interrupt the supra-clavicular nerves, infiltration is carried out along the origin of the deltoid. From three points, situated anteriorly, laterally and posteriorly to the shoulder-joint and united by a curved line extending from the coracoid to the acromion processes and on to the scapula, the capsule of the joint and the internal surfaces of the joint are infiltrated. By this means the twigs supplying the capsule and derived from the supra-scapular and circumflex nerves are interrupted. Should the injection of the plexus in the axilla have failed, the nerve-endings of the N. axillaris (circumflex) are here dealt with.

The third stage consists in infiltrating the line of incision in all its layers from three points ; subcutaneous tissue, muscles and periosteum being all dealt with. The needle should be introduced each time right down to the bone and withdrawn into the subcutaneous tissue, injecting as one proceeds. This line of injection is that laid down by v. Langenbeck as the anterior longitudinal incision along the anterior border of the deltoid.

Finally, Hohmeier infiltrates the transverse section of the limb about 12 to 15 cm. below the joint ; the infiltration includes the muscles and subcutaneous tissues, and is made in order that the anæsthesia may extend further down the limb should the operation be carried downwards.

In all Hohmeier uses about 250 c.c. of 0·5 per cent. solution of novocain-suprarenin, of this 30 c.c. are used for the axillary injection, 30 c.c. for infiltrating the capsule, 70 c.c. for the deep infiltration of the cellular tissues, and 70 c.c. for circum-injecting the transverse plane of the limb and 50 c.c. for the circular infiltration of the subcutaneous tissue. This method of Hohmeier's for anæsthetizing for resections of the shoulder-joint, complicated as it is, is purely an infiltration-anæsthesia. On account of its being so complicated it would appear to be applicable only in a few isolated cases.

Amputations of the arm, fore-arm and resections of the elbow-joint and wrist-joint should be performed under local anæsthesia induced by one of the methods of anæsthetizing the brachial plexus above described. Hohmeier recommends that in addition to plexus anæsthesia the entire cross-section of the limb should be infiltrated a hand's breadth above the line of amputation, and further, that infiltration should be carried into the line of incision into the subcutaneous tissues. He regards this combination of infiltration-anæsthesia with conduction-anæsthesia as an advance, in that the anæsthesia is rendered more certain. One can hardly designate it as an advance, for if the brachial plexus alone be correctly anæsthetized the anæsthesia produced is amply sufficient and Hohmeier's cross section infiltration is quite superfluous.

Anæsthesia of the Veins.

Anæsthesia of the veins first mentioned by Bier in 1908 was again described by Haertel at a later date, and is applicable to the limbs and shall therefore be discussed here. Its applicability is not only to the arm but also to the leg. The principle of the method consists in injecting a certain amount of anæsthetizing fluid, novocain-suprarenin solution, into a subcutaneous vein that has been exposed. The most important condition is that the segment of the limb in question should be absolutely emptied of blood. This is attained in the following manner: The limb is raised and bandaged with a rubber bandage from the fingers (or toes) towards the proximal end to just above the point of injection. Close above this Esmarch's compression is applied by means of another bandage. The first bandage is now removed up to a point close above which a second Esmarch's compression is to be applied. The space between the two Esmarchs should not be less than 25 cm. (one to three hand-breadths). For peripheral segments of the limb one proximal bandage will suffice, but it should not be applied higher than the middle of the leg, or forearm.

When the expelling bandage is removed the limb must be

absolutely depleted of blood and should be quite white; if the slightest tinge of redness or blueness remains in the skin, the success of the anæsthesia is doubtful. After the lower compressing bandage has been applied the expelling bandage can be removed entirely.

Between the two compressing bandages there is now a bloodless segment of the limb.

One of the large superficial veins (basilic, cephalic, median, great saphenous) is now exposed below the level of the upper compressing bandage, anæsthesia being obtained by infiltration wheals. The vein must be accurately localized before the bandages are applied, or it may be difficult to find. The vein having been dissected out, it is ligatured at the proximal end as high as possible. A second ligature is passed under the vein but not tied. By means of the second ligature the vein is raised out of the wound and incised on one side by means of sharp scissors. The cannula is now inserted into the lumen of the vein; it is attached to a so-called Janet syringe of 50 to 100 c.c. capacity, filled with 0·5 per cent. novocain solution without any added suprarenin. The cannula introduced into the vein should have a stop-cock and be connected to the syringe by means of a thick rubber tube. The solution is injected slowly into the vein; for the upper limb 40 to 50 c.c., for the lower 70 to 100 c.c., will be required. Sometimes considerable pressure has to be used in injecting. Having completed the injection one removes the cannula, ligatures the vein, and sutures the wound.

Soon after the injection complete anæsthesia of the section included between the two bandages supervenes (direct anæsthesia).

After a few more minutes (five to fifteen) anæsthesia of the segment of the limb distally to the peripheral bandage is produced, so that the latter can now be removed and the operation commenced (indirect anæsthesia).

The anæsthesia persists as long as the proximal bandage remains applied. The latter is likely to cause discomfort to the patient, so that it is advisable not to prolong the operation unduly.

Before the upper bandage is removed the operation must be quite completed, for as soon as the bandage is removed sensation returns. For accurate stopping of the hæmorrhage in the case of amputations this return of sensitiveness is most disturbing.

By means of this venous anæsthesia all operations on the limbs that can be performed bloodlessly may be undertaken, except in cases of diabetic or senile gangrene.

Arterial Anæsthesia.

This method of local anæsthesia has so far been but little employed. It was used by Goyanes, v. Oppel and Ronsohoff for a few operations on the hand and foot, as well as for amputations. Hotz tested the

method. The brachial, radial, or femoral arteries are exposed according to the requirements of the case, and the limb is constricted proximally to the vessels. The anæsthetic is injected into the artery with a fine needle. For the brachial artery 20 to 25 c.c., for the femoral 40 c.c. of 0·5 per cent. novocain-suprarenin solution are used. Anæsthesia supervenes after about one to two minutes and persists so long as the compressing bandage is left on.

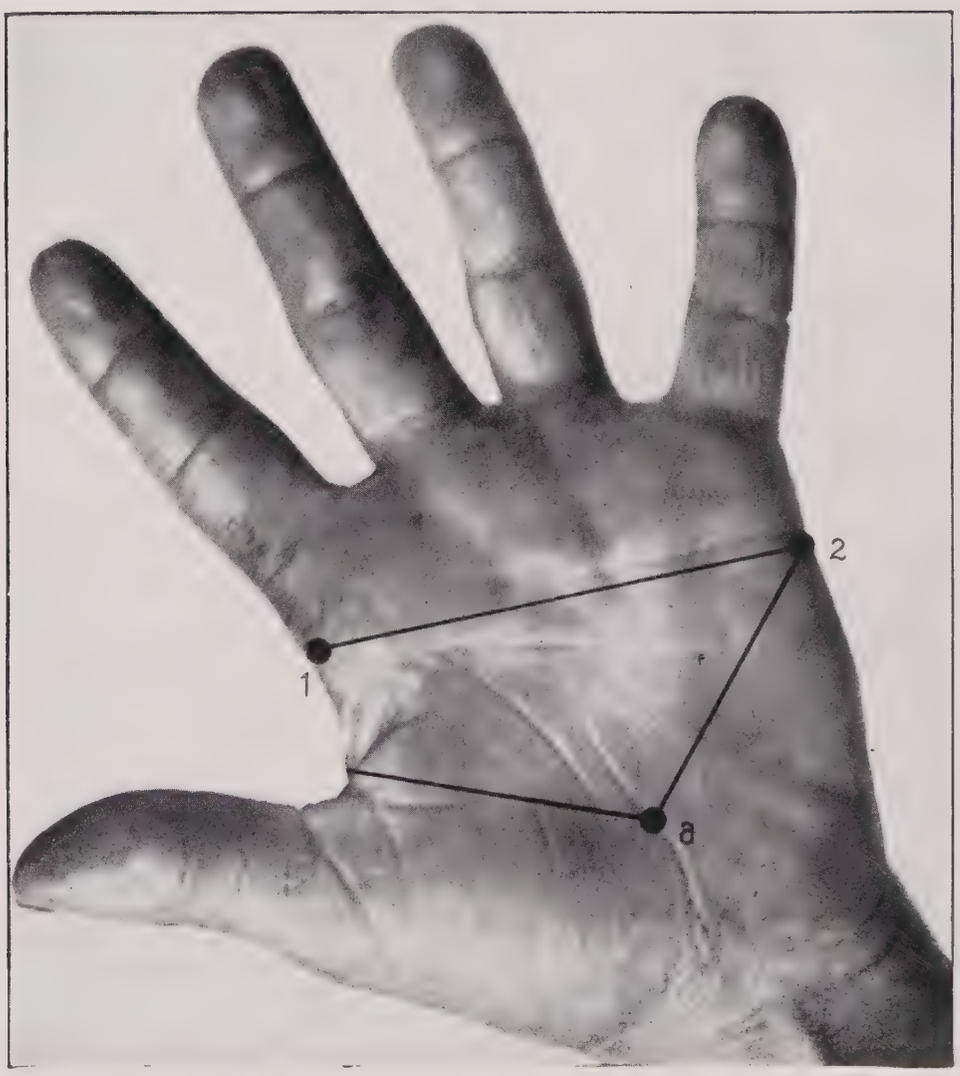

FIG. 86.—Injections for operations on the hand. (Braun.)

Hotz operated on cellulitis and performed amputations and resections under this type of anæsthesia. The drawbacks are much the same as those of the venous method, in that the limb has to be constricted above the point of injection, and that sensibility returns as soon as the bandage is removed. A special drawback is, further, that the artery has first to be found by dissection, and this in itself already constitutes an operation.

Considering the great advances recently made in conduction-anæsthesia of the limbs it is hardly likely that this arterial anæsthesia will be much employed. The venous method has the advantage as compared with the arterial in being more simple of performance.

Operations on the Hands and Fingers.

As we have already mentioned above, all operations on the upper limb may be performed under anæsthesia of the brachial plexus, operations on the hand and fingers also. Since, however, in the case of the comparatively minor operations on the fingers anæsthesia of the whole arm is unnecessary, and since the procedure of Oberst is far simpler and quite reliable, it should be preferred to the more drastic measure.

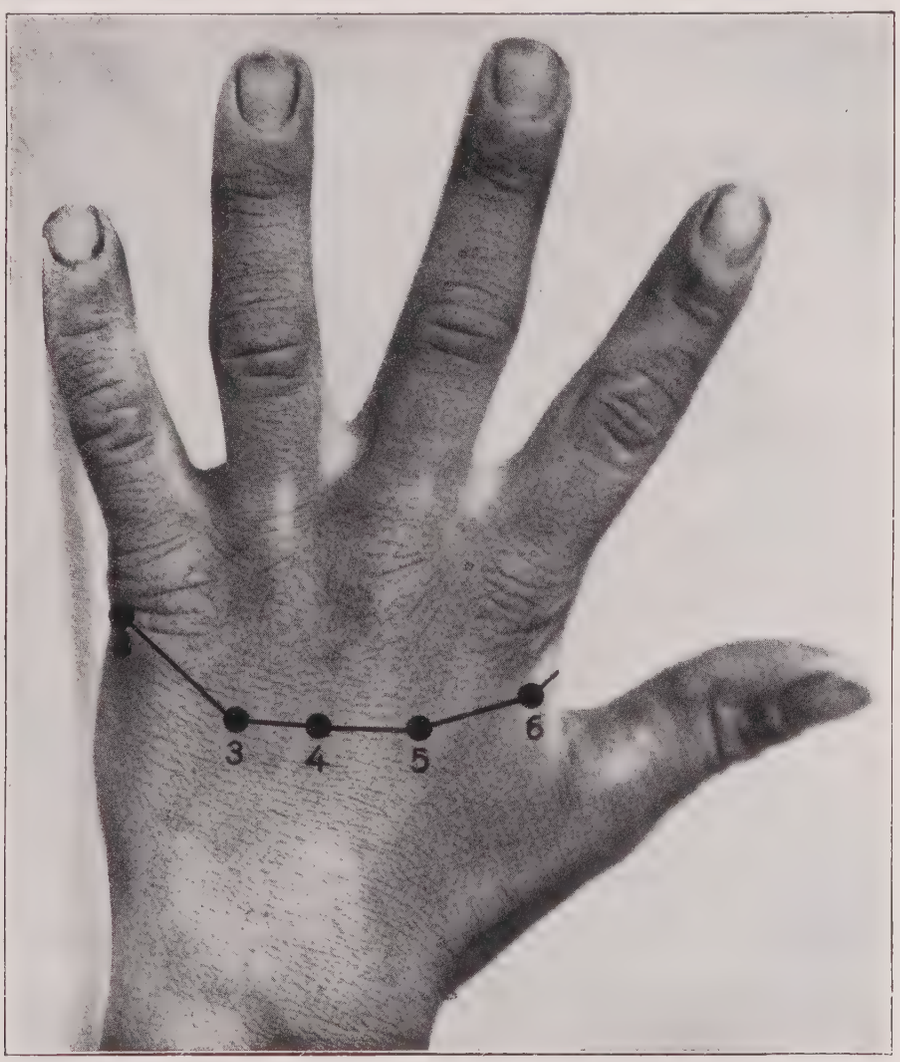

FIG. 87.—Injections for operations on the hand. (Braun.)

In the case of **minor operative procedures** on the hand, such as the removal of foreign bodies, ganglia, removal of sequestra, Dupuytren's contraction, &c., the simple circumscription of the region to be operated on is often to be preferred to anæsthetizing the plexus.

Braun has described several suitable methods of circum-injection, the most important of which we shall now describe. In order to anæsthetize a larger segment of the hand, for instance, the method illustrated by fig. 86 may be employed. A transverse infiltration of the palm of the hand is performed from points 1 and 2; in order to

enlarge the field of operation it is only necessary to inject from point 2 to point *a*, and from here towards the root of the thumb to point 6 in fig. 87. The injections should be both subcutaneous and subfascial as well as intramuscular. Braun recommends this circumscribing infiltration **for operating on Dupuytren's contraction** and for **opening thecal abscesses.**

If the field of **operation** extends to the **metacarpal bones,** the circumscribing infiltration must be carried round to the back of the hand to points 3, 4, and 5, fig. 87, the injections being made between the interosseous spaces.

FIG. 88.—Injections for operations on the thumb and fingers.

To anæsthetize the **ball of the thumb,** required frequently for the removal of foreign bodies, such as needles, &c., and for opening thecal abscesses, the method of procedure should be that depicted in fig. 88. From point 5 infiltrations are carried through two layers of tissue, by subcutaneous and intramuscular injection, along the margin of the muscles of the thumb towards the point *a* in fig. 89. From point 7 the infiltration should also be carried via point 8 to point *a*.

If the **thumb has to be disarticulated** or an operation has to be performed on the first metacarpal bone, the needle is carried, infiltrating as it proceeds, through the interosseous space from point 6, fig. 88, to the point *a*, fig. 89. From point 5 subcutaneous injections are made towards point 6, then into the deeper layers along the first metacarpal bone to the carpo-metacarpal articulation, finally deep infiltration along the ulnar border of the ball of the thumb to the point *a*. The same injection is repeated subcutaneously. Finally, a subcutaneous circumscribing infiltration is made through 6, 7, 8, to *a*.

FIG. 89.—Injections for operations on the thumb and fingers.

For **exarticulating the middle finger** the following scheme may be followed (figs. 88 and 89): Four points of injection have to be taken 1, 2, 3, 4, in fig. 88. Of these 1 and 2 are situated on the interdigital folds, 3 and 4 on the dorsum of the hand in the intermetacarpal spaces. From point 3 the needle is introduced through the skin and the third interosseous space, infiltrating as one proceeds towards the point *b*, fig. 89. The same is done from point 4 through the second interosseous space. From point 1 the needle is again introduced and subcutaneous infiltration carried towards point *c*, as well as deep infiltration between the third and fourth metacarpal

bones and under the skin of the palm to point *b*, fig. 89. Similar injections are made from point 2.

To anæsthetize **the ball of the little finger** infiltration is carried along the muscles of the hypothenar as well as subcutaneously from the point 10, fig. 88, situated on the interdigital fold to the point *a*, fig. 89. Finally, from point *b*, fig. 89, subcutaneous infiltration

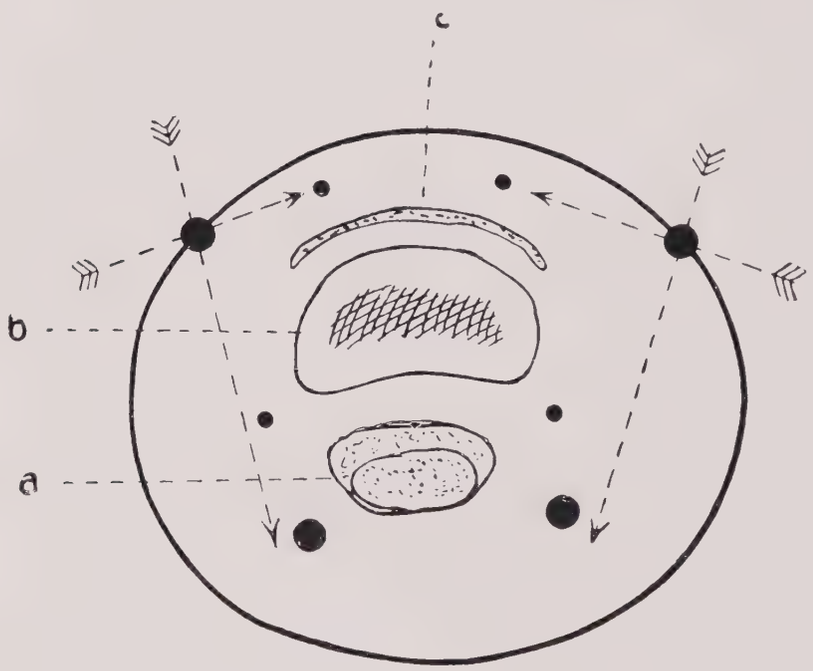

FIG. 90.

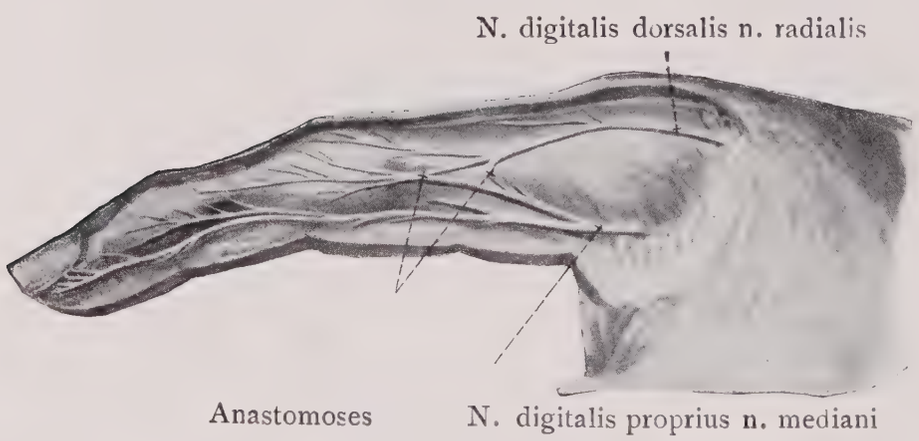

FIG. 91.—(After Spalteholz.)

is carried to point *a*, and along the ulnar border of the hand towards the little finger. The same anæsthetic result may be obtained in a simple manner by injecting the ulnar nerve at the elbow.

To **anæsthetize the individual fingers Oberst's method** is very simple. The constriction of the basal phalanx of the finger by means of a rubber ring or piece of rubber tubing, as recommended formerly according to Oberst's method, has become superfluous since the introduction of adrenalin into local anæsthetic practice. Fig. 90,

taken from Braun's "Lokalanæsthesia" shows a transverse section of a finger at the level of the basal phalanx; *a* is the cross-section of the flexor tendons, *b* that of the bone, *c* that of the extensor tendons. The paired points are the transverse sections of the nerves of the finger. The thickest pair is on the palmar surface near the flexor tendons; from it at the base of the basal phalanx a second pair branches off which gradually passes to the dorsal surface and there innervates the extensor tendon of the second and third joints, fig. 91. The cross-section of this pair is shown between the bone and the flexor tendons in fig. 90. A third, delicate, pair runs dorsally under the skin and usually ends in the basal phalanx (figs. 90, 91).

FIG. 92.—Injections for operations on the fingers. (Oberst's method.)

The technique of the injection is as follows: Two points of puncture are necessary, situated one on each side of the finger, preferably of the basal phalanx (fig. 92). They are situated more towards the extensor surface (fig. 90). The solution should be injected intra-cutaneously from the moment the needle is introduced, whereby a small wheal is produced. The needle is now turned across the longitudinal axis of the finger subcutaneously towards the flexor tendons, 1 to 2 c.c. of 1 per cent. solution of novocain-suprarenin being injected as one proceeds. Then the needle is again retracted and turned in the other direction towards

the extensor tendons, the same amount being injected (the directions are indicated by arrows on fig. 90). The same procedure is repeated from the second point of insertion. During the injection the finger that is being anæsthetized is kept extended, the other fingers being flexed. As we have already said, the finger need not be constricted. Anæsthesia supervenes on an average after three to five minutes, and persists for from one to two hours. The method is suitable for all operative procedures on the soft parts and bones of the fingers; it is probably most frequently employed for opening whitlows.

Local Anæsthesia in Operations on the Lower Limb.

Local anæsthesia in operations on the lower limb has not kept pace with the advances of that of the upper limb. The anæsthetization of the lumbar plexus in a manner analogous to that of the brachial has not so far been successful. This is readily explicable on account of the anatomical relations of the plexus of nerves supplying the leg, which is not situated in as favourable a manner as the brachial plexus is, and cannot be reached percutaneously by the injecting needle.

The lumbo-sacral plexus forms an extensive complex of nerves which are distributed over a wide area.

The lumbar plexus is formed by the three first and a part of the fourth lumbar nerves, and receives twigs from the last intercostal nerve. It is situated anteriorly to the transverse processes of the lumbar vertebræ medially to the psoas major muscle.

From our point of view the most important branches are: the N. ilio-hypogastricus, which has already been described under the heading of inguinal hernia, in dealing with which it has to be considered. The ilio-inguinal and N. genito-femoralis (genito-crural) are likewise nerves that were dealt with there. The N. cutaneus femoris lateralis (external cutaneous) takes its course downwards close to the anterior iliac spine; its branches are distributed to the skin of the lateral surface of the thigh as far as the knee and anastomose with the cutaneous branches of the N. femoralis (anterior crural) (fig. 94 *a*). As it supplies a wide strip of integument of the lateral surface of the thigh the interruption of its conduction produces an extensive anæsthetic area (Nystroem). The method employed for anæsthetizing it will be described later.

The N. femoralis (anterior crural) is the largest nerve of the plexus (fig. 93); it takes its course downwards and laterally behind the psoas

major muscle to beneath the inguinal (Poupart's) ligament where it divides into its terminal branches. In the ilio-pectineal groove the nerve lies laterally (external) to the artery.

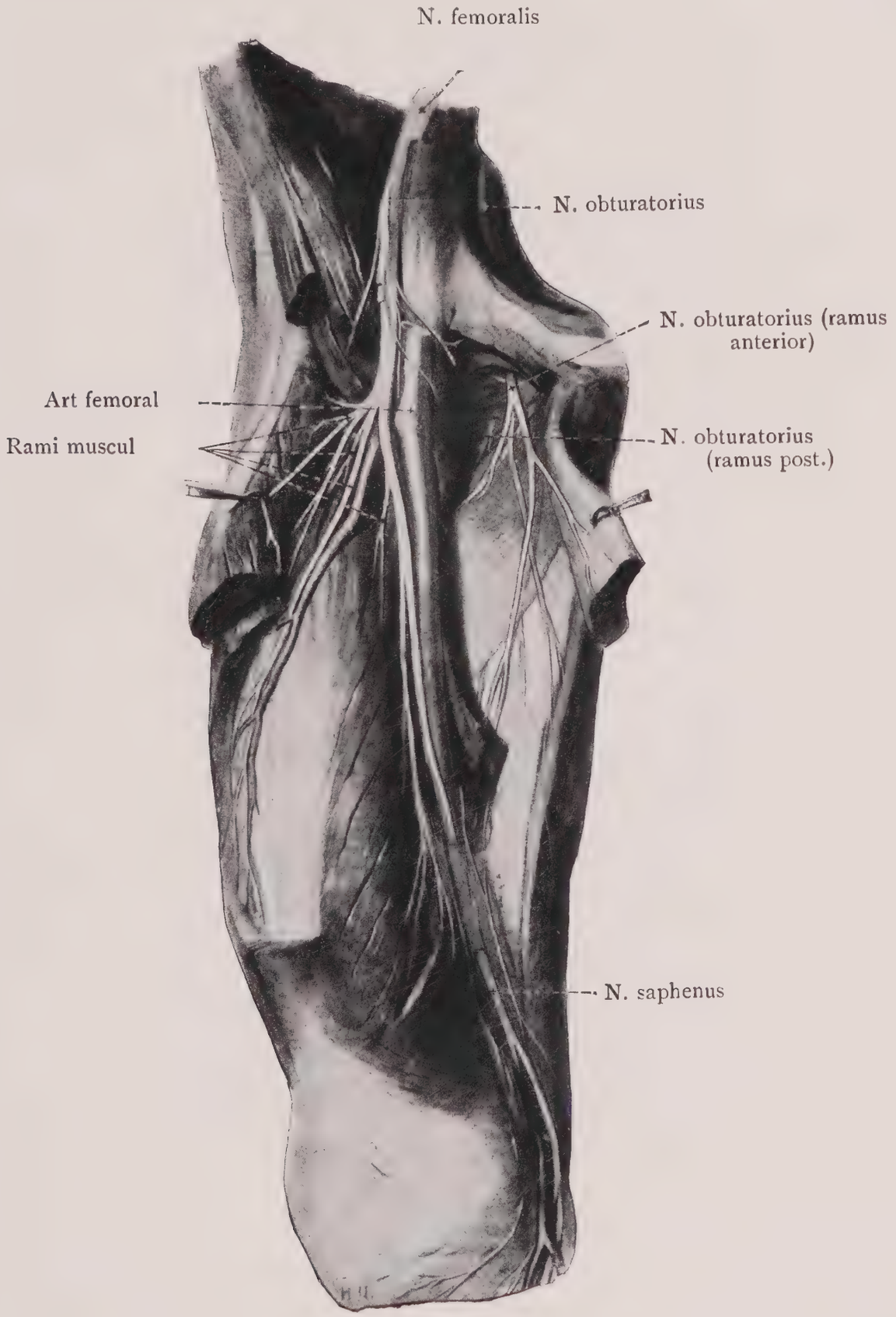

FIG. 93.—(After Spalteholz.)

Of its branches the important ones for us are : the sensory twigs to the capsule of the hip- and knee-joints (the upper part of the hip-joint and the knee-joint is supplied by the N. femoralis, the lower part

of the hip-joint by the obturator nerve), anterior cutaneous branches (fig. 94 *b* and *c*) which pierce the fascia high up laterally (externally) to the fossa ovalis (saphenous opening). The main nerve continues as the N. saphenus (long saphenous nerve), which pierces the fascia ilio-pectinea a little above the middle of the thigh and reaches the artery in the canalis adductorius (Hunter's canal); 4 to 5 cm. below the upper end of the latter it pierces the anterior wall of the canal, runs

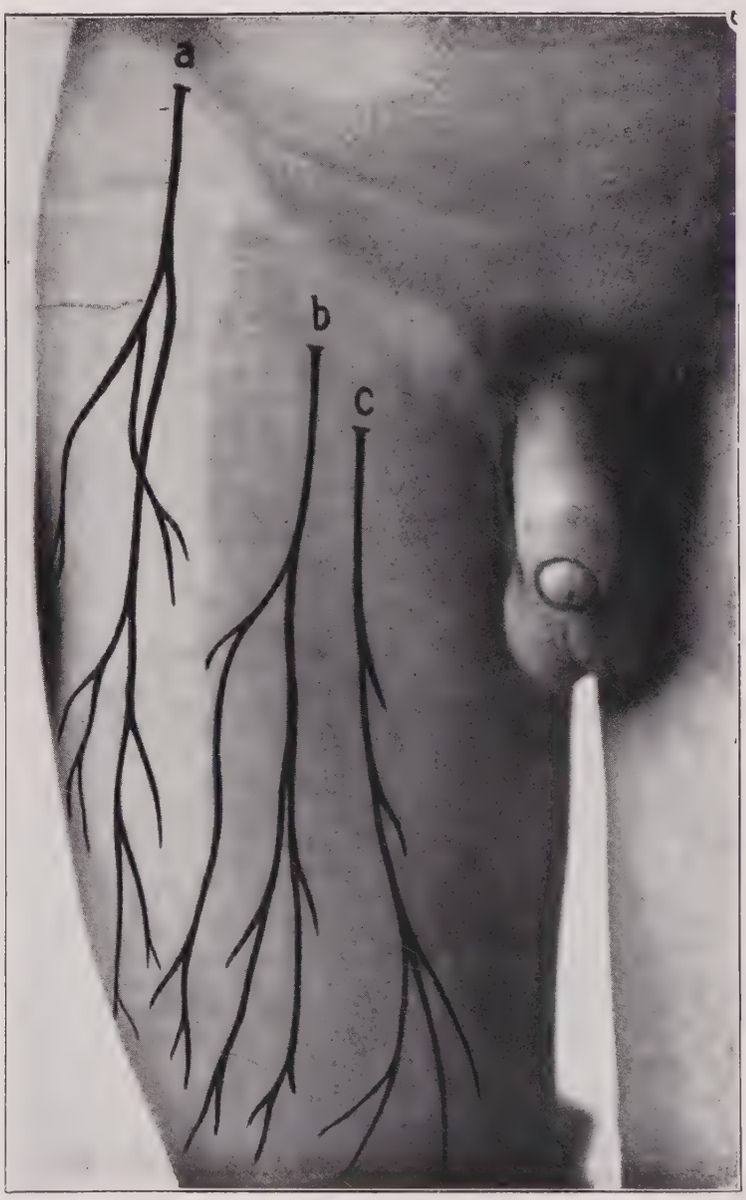

FIG. 94.—a, N. cutaneus femoris lateralis ; b and c, Rami cutanei ant. n. femoralis.

along the posterior border of the sartorius downwards behind the epicondylus medialis (inner tuberosity), pierces the fascia at the level of the tuberositas tibiæ (the tubercle) and divides into its terminal branches. These are the ramus infra-patellaris (patellar) which goes to the patella, supplying the skin anterior and inferior to it; and the continuation of the main nerve which courses downwards along the vena saphena magna (internal saphenous) to the middle of the foot (fig. 95).

The N. obturatorius (fig. 93) at first descends in the psoas leaving it at its medial surface in front of the sacro-iliac articulation and passing below the pelvic brim on the pelvic fascia forwards to the

FIG. 95.—(After Spalteholz.)

obturator canal (groove), in which it gives off a branch to the external obturator muscle, and then divides into two branches, the posterior (deep), which mainly supplies the hip-joint, and the anterior (superficial)

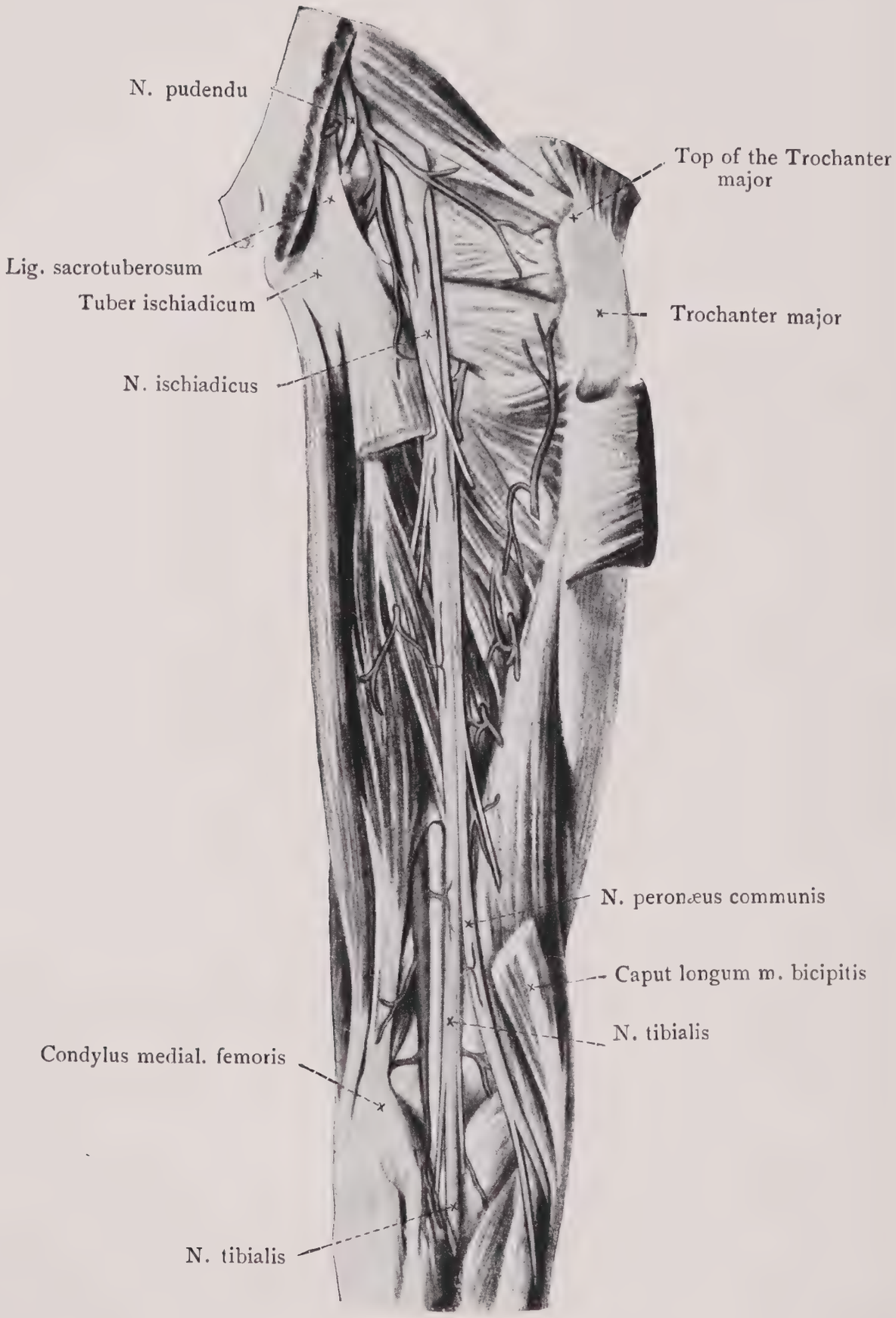

FIG. 96.—(After Corning.)

branch, which, after giving off motor branches, pierces the fascia about the middle of the thigh as the cutaneous branch to reach the skin and supplies the lower half of the medial side of the thigh.

The plexus sacralis is formed by a part of the fourth and the whole of the fifth lumbar nerve and the first three sacral nerves. It is situated on the anterior surface of the pyriformis muscle as far as the superior margin of the coccygeus muscle.

The main branches supplying the limb are: the N. cutaneus femoris posterior (small sciatic), which passes through the foramen ischiadicum majus behind the sciatic nerve and lateral (external) to the inferior gluteal artery and vein. In the groove between the semitendinosus and biceps muscles it runs to the popliteal space under the fascia lata, it sends off thicker medial (internal) and weaker lateral (external) branches through the fascia to the skin of the posterior surface of the thigh and calf.

The N. ischiadicus (great sciatic nerve), the thickest nerve in the body, passes through the foramen ischiadicum majus (great sciatic notch) posterior to the gemelli muscles, the tendon of the obturator internus muscle and the quadratus femoris, about half way between the trochanter majus (great trochanter) and the ischial tuberosity in front of the N. cutaneus femoris posterior (small sciatic) downwards. It then passes along the posterior surface of the adductor magnus in front of the long head of the biceps to the upper angle of the popliteal space where it divides into the N. tibialis (internal popliteal nerve) and the N. peronæus communis (external popliteal nerve). In about 15 per cent. of the cases the division takes place already at the plexus (fig. 96).

The N. tibialis runs almost vertically in the middle of the popliteal space between the condyles to its lower angle, and there dips to a deeper level between the two heads of the gastrocnemius muscle. In the popliteal space the nerve lies directly beneath the fascia, to the dorsal and lateral (external) side of the popliteal vein, which in turn lies dorsally and laterally to the artery (fig. 97).

The main branches are the N. cutaneus suræ medialis (communicans tibialis), which runs towards the groove between the two heads of the gastrocnemius and descends beside the short saphenous vein; near the top of the Achilles tendon it pierces the fascia. It supplies a cuneiform segment of the dorsal and lateral cutaneous surface of the calf, and by its rami calcanei laterales the dorsal and lateral surfaces of the skin of the heel. As N. cutaneus dorsalis lateralis it takes its course along the lateral (external) border of the foot to the base of the last phalanx of the fifth toe.

Further, the internal popliteal nerve gives off articular branches to the knee-joint. One of the terminal branches of the internal popliteal, the N. plantaris medialis, supplies the sensory innervation

to the medial border of the great toe and the interdigital surface of the second to fourth toes; the anterior part of the sole of the foot also receives sensory twigs. The N. plantaris lateralis supplies the fifth toe and the remaining side of the fourth.

The N. peronæus communis (external popliteal nerve) (figs. 97, 98) courses along the medial border of the biceps femoris behind the head of the fibula to the lateral border of its neck, where it divides into its two terminal branches, the N. peronæus profundus (anterior

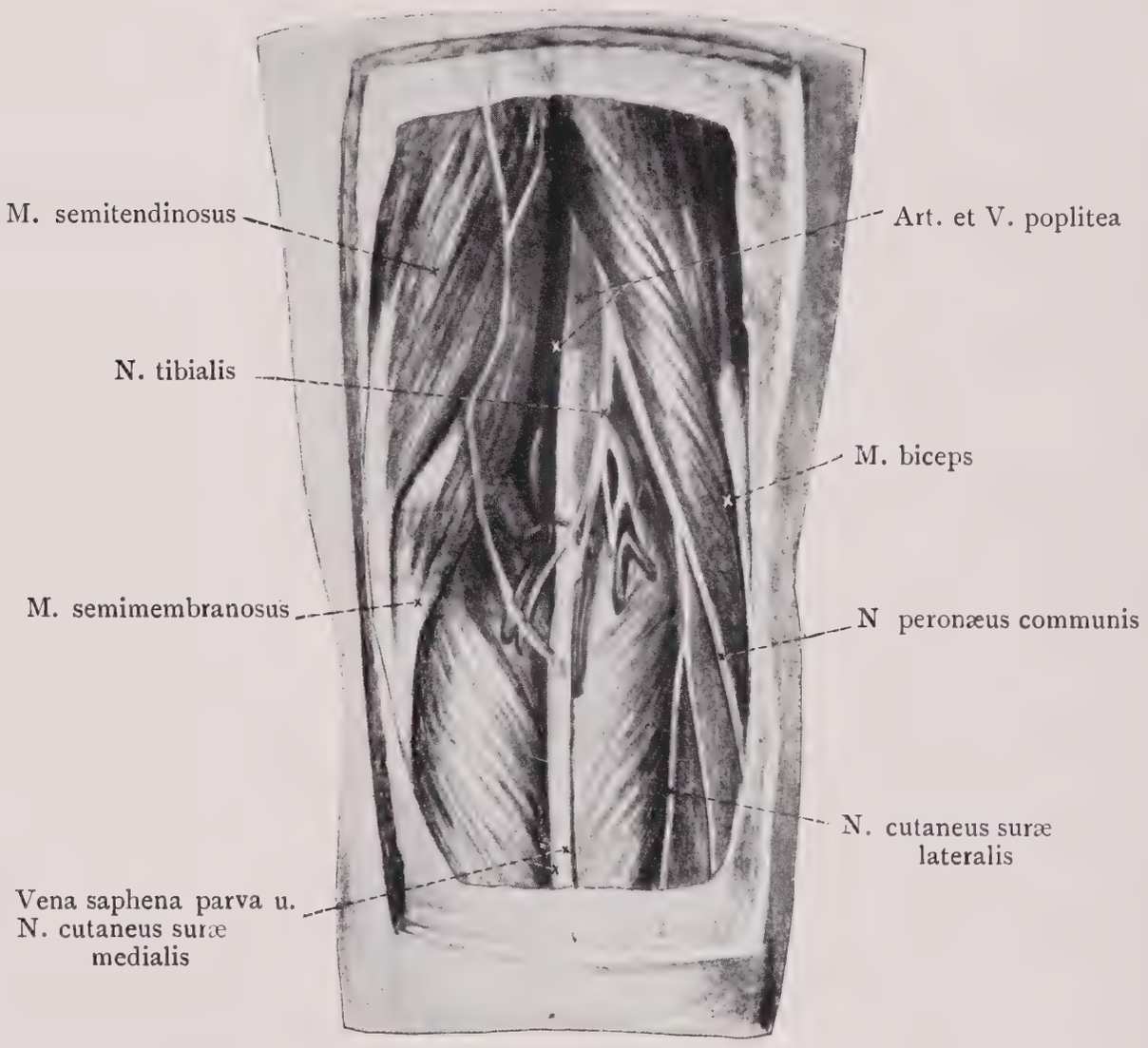

FIG. 97.—(After Corning.)

tibial) and superficialis (musculo-cutaneous). Before dividing into these branches the external popliteal nerve gives off an articular branch to the knee and tibio-fibular joints as well as the N. cutaneus suræ lateralis, supplying sensory twigs to the skin of the lateral half of the leg as far as the lateral (external) malleolus.

The N. peronæus profundus (anterior tibial) gives off, besides muscular branches, a cutaneous branch to the interdigital surfaces of the first and second toes (fig. 98). The N. peronæus superficialis (musculo-cutaneous) innervates the peroneal muscles, and as the

N. cutaneus dorsi pedis medius the medial (internal) border of the great toe and the interdigital surfaces of the second and third toes, and finally as the N. dorsi pedis intermedius the borders of the third and fifth toes (fig. 98).

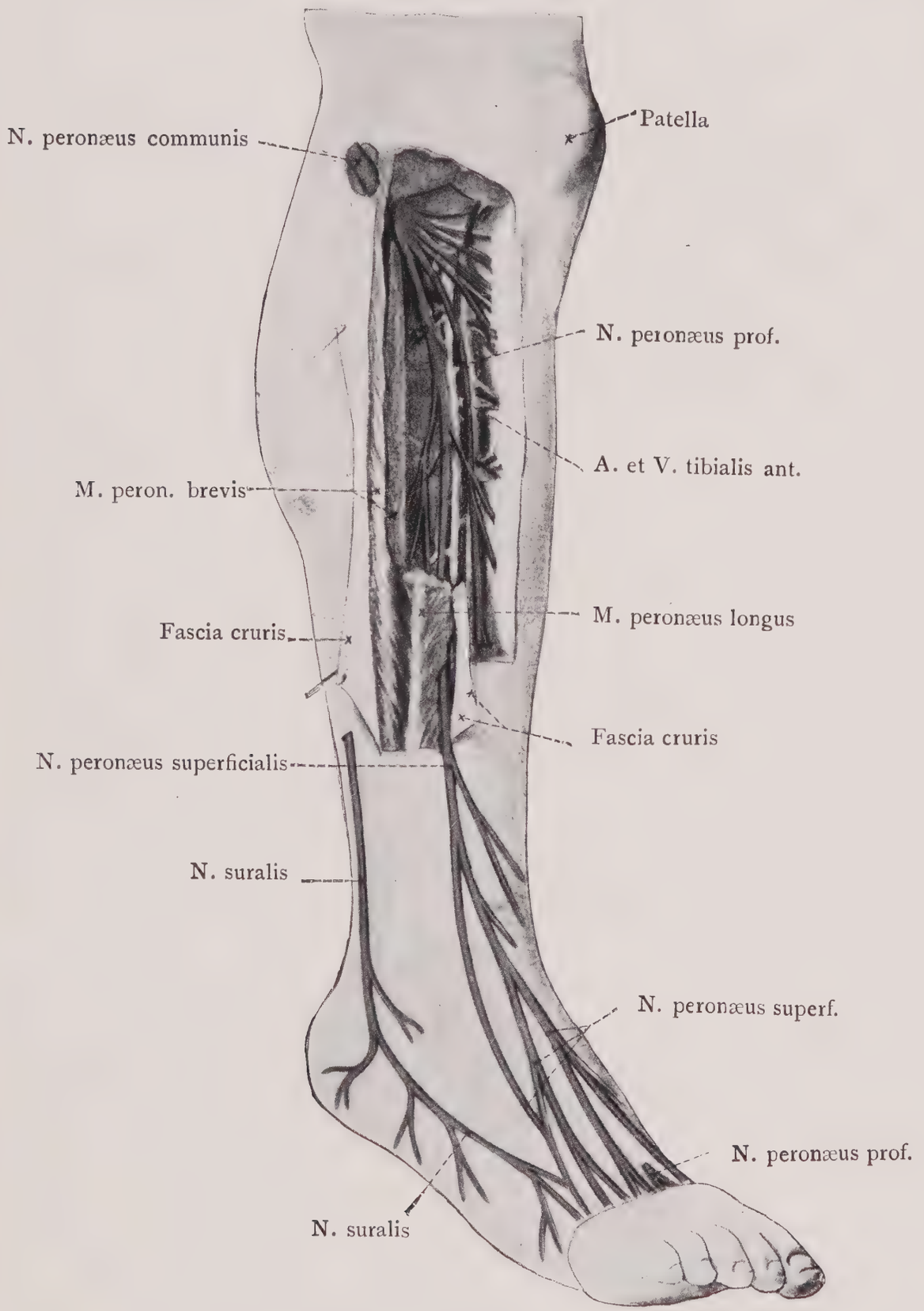

FIG. 98.—(After Corning.)

Notwithstanding the fact that up to the present time no success has attended the attempts to anæsthetize the lumbo-sacral plexus, the advances in the field of local anæsthesia as applied to the lower

limb have been so great that it has become possible to procure satisfactory results in this region also by local anæsthetic methods.

Already in the early days of local anæsthesia Braun pointed out that conduction-anæsthesia in the popliteal space and the leg could be carried out; he had no success in the thigh. To anæsthetize the latter we must, since we cannot attack the plexus, be content with percutaneous perineural injection of the nerves that have to be taken into account, and since we are able to make use of larger and more concentrated quantities of novocain-suprarenin solution than was formerly the case, there is a possibility of the anæsthetic penetrating into the nerves.

For determining the site for injection of the individual nerves we have osseous guides, though in some cases we have to be satisfied with injecting in the direction in which the nerve may probably be found, and with guiding points provided by the soft parts.

To obtain anæsthesia of the whole leg five nerves have to be interrupted in their conduction. These are: the great sciatic, the small sciatic, the anterior crural, the obturator and the external cutaneous nerves (Nn. ischiadicus, cutaneus femoris posticus, femoralis, obturatorius and cutaneus femoris lateralis).

Nystroem was the first to interrupt the conduction of one of these nerves, true, only a cutaneous one, the **N. cutaneus femoris lateralis.** By anæsthetizing this nerve it is possible to deprive a large strip of skin on the lateral side of the thigh, from which pieces of integument may be taken for skin-grafting purposes. Nystroem's method is as follows: Close to the inner border of the anterior superior iliac spine and below it 4 to 5 c.c. of 1 per cent. novocain-suprarenin solution are injected to various depths into the fascia lata. After ten minutes analgesia of the area of skin on the outer side of the thigh is obtained. As the course of the nerve varies considerably the method is not always reliable.

Laewen was the first to interrupt all five nerves of the leg and thereby produce anæsthesia of the whole limb. He recommends Nystroem's method in the case of skin-grafting operations combined with anæsthesia of the **N. femoralis** (anterior crural). By this means an extensive area on the anterior surface of the thigh is rendered anæsthetic as well. The method is as follows: The femoral artery is felt for and fixed by the fingers of the left hand; a superficial cutaneous wheal is then infiltrated directly below Poupart's ligament about 1 to 1·5 cm. external to the artery. Through this wheal the needle, which should be long and fine, is introduced vertically deeply under the fascia. It is easy to tell by the feeling when the needle penetrates the latter, and the needle should be pushed onwards for another 0·5 to 1 cm. from this point. It is sufficient to inject 5 c.c. of 2 per cent. solution of novocain-bicarbonate-adrenalin, which Laewen uses.

Laewen observed that after anæsthesia had persisted in the thigh for about twenty minutes, an anæsthetic area developed on the inner side of the leg, the area of distribution of the N. saphenus (long saphenous), a certain proof that the conduction of the main trunk of the anterior crural had been interrupted.

Keppler gives a similar description of the method for anæsthetizing the N. femoralis (anterior crural) ; he injects 10 c.c. of 2 per cent. novocain-suprarenin solution.

Interruption of the conduction of the **N. ischiadicus** (great sciatic) had already been performed by Crile it is true, but only by laying bare the nerve in the gluteal fold and injecting cocaine or eucaine solutions, in a manner analogous to that he employed on the brachial plexus.

The **method suggested by Laewen** for interrupting the conduction of the great sciatic nerve is as follows : The patient should be in the prone position. The points of injection are indicated by two infiltration wheals, one about 2 cm. external to the tuberosity, the other 3 cm. internal to the great trochanter. From the former the needle is introduced deeply and vertically until the point is reached where, as the result of previous palpation, one expects to find the nerve. Laewen injects 20 to 30 c.c. of 1 per cent. solution of novocain-bicarbonate-adrenalin at this spot. The object of this injection is to interrupt the conduction of the **internal popliteal nerve (nervus tibialis)** which is difficult to strike. A certain quantity of the solution is also deposited somewhat externally to the first point. The second injection is given at the outer of the two points. Since the nerve is situated more towards the tuberosity the needle should be inclined somewhat point inwards (fig. 96). Three layers of tissue are injected in this case ; the first is situated deep down just outside the nerve, the second rather more superficially and the third still more so. From the two last layers the needle is advanced towards the tuberosity, injecting all the time. By this means the **N. cutaneus femoris posterior** (small sciatic) is interrupted. For the anæsthetization of the N. tibialis (internal popliteal) Laewen uses a small quantity of 3 to 4 per cent. novocain-bicarbonate-adrenalin solution.

Keppler recommends that the **N. ischiadicus** should be interrupted at the point where it emerges through the **great sciatic notch**, partly in order that it may be struck more proximally when undivided, partly in order to be certain of anæsthetizing the N. cutaneus femoris posterior (small sciatic) which lies on the great sciatic at the foramen, and finally in order to localize the nerve by bony guiding points as is possible in this region. The method suggested by Keppler is as follows : The patient being in the prone position, the pelvis being raised by a pillow in order to render the bony points more prominent, an imaginary line is drawn from the posterior

superior spine of the ilium to the outer border of the ischial tuberosity ; a little below the middle of this line a cutaneous infiltration wheal is made in the skin. This wheal lies in the same level as the point of the trochanter and indicates the spot where the great sciatic, with the small sciatic on it, leaves the cavity of the pelvis. The needle is now introduced deeply and vertically at this wheal, the point of the needle as a rule first reaching the posterior surface of the ilium ; this indicates that the needle has gone too far and past the nerve ; it is therefore slightly retracted and again pushed onwards, either to the right or left of the first direction until a pain in the leg indicates that the nerve has been found. Keppler usually observed lightning-like pains, sometimes paræsthesias in the calf, soles of the feet and toes.

The amount of solution injected by Keppler is 20 to 30 c.c. of 2 per cent. novocain-suprarenin solution or 10 c.c. of the 4 per cent. solution. Anæsthesia supervenes in a few minutes ; the sooner it appears the more certain will be the success of the injection.

Similar to Keppler's method is that described by **Jassenetzki-Woino.** He also tries to strike the nerve just as it leaves the great sciatic notch. The patient being in the prone position, the great trochanter and the ischial tuberosity are palpated. A rectangle constructed of steel-wire is placed on the buttock in such a manner that one of its sides passes horizontally through the point of the great trochanter and the other through the external margin of the tuberosity. At the apex of the angle an 8 cm. long needle is introduced vertically into the deep tissues till it strikes on bone, the needle is then retracted a few millimetres and 10 c.c. of 2 per cent. novocain-suprarenin solution injected. This amount is sufficient for operations on the soft parts ; for operations on the bony tissues 15-20 c.c. should be injected. In the former case the operation can be commenced half an hour after the injection. In the latter about one hour should elapse.

The last nerve requiring anæsthetization is undoubtedly the most difficult of all the nerves of the leg, namely the **N. obturatorius. Laewen** describes the following method : About the middle of the inner surface of the thigh several cutaneous wheals are infiltrated in a transverse line. The whole layer of tissue at a depth of 4 to 5 cm. is now infiltrated from these wheals, injecting in a somewhat inclined direction ; by this means the sensory twigs of the obturator nerve are interrupted. Finally, Laewen produces a strip of infiltration subfascially and subcutaneously under the wheals. The solution he uses is the 0·5 to 1 per cent. novocain-suprarenin. This method of Laewen's can hardly be described as ideal, for without guides of any kind the entire layer of tissue in which the branches of the obturator nerve might run is infiltrated. The supervening of the expected anæsthesia is therefore very uncertain.

Keppler believes he has found a better solution of the question, in looking for the nerve at the point where it leaves the obturator groove. His method is as follows: The tuberculum pubicum (pubic spine) is first found by palpation, and a wheal infiltrated about one thumb's breadth below this point. From the latter the needle is introduced down to the bone, and, keeping constantly in touch with the horizontal ramus, is then advanced in a transverse and somewhat upward direction outwards until bony resistance is met with, which is the junction between the horizontal ramus of the pubis and the descending ramus of the ilium. The position of the point of the needle is now quite close to the obturator groove, and about 10 c.c. of 2 per cent. novocain-suprarenin solution should deposited at this spot. Not infrequently the needle passes into the obturator groove itself. As the needle is advanced along the horizontal ramus of the pubic bone, pain radiating along the inner surface of the thigh is apt to be complained of; it is therefore well to inject a little of the solution as one advances the needle. This method of Keppler's for the anæsthetization of the obturator nerve certainly offers a more certain chance of striking the nerve than does the Laewen method.

The finding of the great nerves of the leg with the injecting needle, and even the perineural injection of the nerves with novocain-suprarenin solution in such a manner as to be moderately certain that the solution will reach them and penetrate into them, meets with several difficulties. In the first place it depends on the personal dexterity of the operator, but it also depends on the patient. Large adipose deposits may cause complete failure, and anatomical anomalies may lead to the same result.

For this reason **Perthes** has devised a **method** by which with the aid of electric stimulation the nerve can be more easily localized. He uses a nickel needle which is treated with electrically non-conducting varnish. A weak faradic current is allowed to pass along the needle, so that muscular contractions occur only when the nerve is struck; even if the needle be only 1 mm. distant from the nerve, these contractions do not occur. The needle connected with the electrical apparatus is already attached to the syringe, so that the injection can be carried out the moment the muscular contractions take place, the syringe having previously been charged with 2 to 3 per cent. novocain solution. Even with his method Perthes has met with some failures, so that further trials and perhaps some modifications may be necessary.

The method of anæsthetizing **for a resection of the hip** according to v. Langenbeck's method is thus described by Hohmeier. In the first place the N. femoralis (anterior crural) and the N. ischiaticus (great sciatic) are anæsthetized perineurally. Although the interruption of the conduction of these nerves is not absolutely necessary, Hohmeier recommends it as contributing to the infiltration of the

tissues. Then the capsule of the joint is anæsthetized; for this purpose the needle is introduced from the great trochanter along the anterior and posterior surfaces of the neck of the femur towards the joint, and the injection is made as the needle is withdrawn. Next, a subcutaneous infiltration is carried along a line running transversely above the line of incision to interrupt the conduction of the Nn. clunium superiores (superior gluteal nerves). Thereupon follows infiltration along the line of incision into subcutaneous, muscular, and deep tissues down to the bone. Finally, Hohmeier infiltrates the cross section of the thigh subcutaneously, about 15 cm. below the level of the great trochanter. The whole procedure requires about 300 c.c. of 0·5 per cent. solution, and anæsthesia supervenes in ten minutes.

For the **reduction of dislocations of the hip-joint**, Braun describes the following method: The head of the femur having been located by palpation, about 25 c.c. of 1 per cent. novocain-suprarenin solution are injected towards it, and another 20 c.c. into the acetabulum. The latter is located as follows: A 10 cm. long needle is introduced close behind the anterior superior spine, and advanced in the direction of the acetabulum, keeping in touch with the bone until the joint is reached. The appearance of a few drops of blood at the orifice of the needle shows that the joint has been reached. The injection is then made.

Braun has observed that the previously rigid leg becomes movable almost immediately after the injection; a few minutes later the reduction can be undertaken painlessly.

In the case of **fractures of the leg,** the setting of them may be performed under local anæsthesia by employing the method of Lerda, Quénu, and Braun, in a manner similar to that used for fractures of the upper limb. The method consists in injecting 0·5 to 1 per cent. novocain-suprarenin solution from several points and in several directions on to the ends of the fractured bones. In the case of fractures involving the joint the injection is made directly into the joint.

In inducing local anæsthesia for **amputations of the thigh** the Nn. femoralis (anterior crural), cutaneous femoris lateralis (external cutaneous), obturatorius, ischiadicus (great sciatic), and cutaneous femoris posterior (small sciatic) must be interrupted.

The methods used for anæsthetizing these nerves have already been described above.

In the case of the lower limbs also Hohmeier recommends that cross-section infiltration should be carried out above the point of severance of the bone, subcutaneous injections being used, in addition to the conduction-anæsthesia of the N. ischiadicus and N. femoralis. Avoiding the big vessels the whole of the layers of tissue, sub-

cutaneous, muscular, periosteum, are infiltrated with 0·5 per cent. novocain-suprarenin solution. Further, he recommends separate infiltration of the line of incision. The operation can be commenced about half an hour after the injections have been given.

This procedure of Hohmeier's of infiltrating the limb down to the periosteum, in addition to interrupting the conduction of the main nerves, is more justifiable in the case of the lower limb than in that of the upper. As we have seen above, the performance of perineural anæsthesia on the large nerves of the leg offers several difficulties, so that one or the other of them may fail to be anæsthetized; hence Hohmeier's infiltration of the cross-section of the leg may be of use to supplement the other should failure occur.

Anæsthetization **of the leg and foot** is easier to perform than that of the thigh.

The nerves that have to be considered are: Nn. tibialis (internal popliteal), peronæus (external popliteal) and saphenus (long saphenous). The two first may often be met with as one trunk; as a rule the point of division is at the upper angle of the popliteal space where the common trunk appears in front of the long head of the biceps. In 15 per cent. of the cases, however, the division takes place already in the plexus, and this fact must be taken into account when making the injection.

If one wishes to strike the common trunk the needle must be inserted at the upper angle of the popliteal space where the biceps and the semitendinosus and semimembranosus diverge (fig. 97). Since the nerve lies directly against the muscle, the injection should be made at the medial (internal) border of the biceps somewhat laterally (externally) from the middle line of the popliteal space. The artery and nerve lie medially (internal) to the nerve (fig. 97). This method is uncertain, however, owing to the possibility of high division of the nerve.

Far more reliable is the injection of the separate nerves. Such a method is that formerly practised by Braun with success, and for a long time used in the Heidelberg clinic as reliable and typical. The needle is introduced vertically, exactly in the middle line of the popliteal space, perhaps slightly external to it, to a depth of from 1 to 0·5 cm. (fig. 99, point *b*). If the **N. tibialis** (internal popliteal) be at once struck by the needle, as is often the case, paræsthesias occur in the leg. An injection of 10 c.c. of 2 per cent. novocain-suprarenin solution is sufficient. The needle must not be introduced too deeply, or one may miss the nerve and reach the vessels. Together with the internal popliteal nerve the Nn. surales (short saphenous) are injected perineurally.

The injection of the **N. peronæus** (external popliteal) can be performed in a more simple manner at the point where it lies

directly behind the head of the fibula and can usually be felt (fig. 98). Here another 10 c.c. of the same solution should be injected (fig. 101, point *a*).

Finally, there remains the anæsthetization of the **N. saphenus (long saphenous)**. As we have seen above, this nerve runs along the inner side of the thigh to the leg, and usually lies behind the saphenous vein. It gives off infra-patellar branches and cutaneous

Fig. 99.

Fig. 100.

Fig. 101.

branches to the leg (fig. 95). The nerve is easily interrupted by subcutaneous infiltration along a line below the knee-joint at the inner surface of the leg; this line is shown at *a b* in fig. 100; 10 c.c. of 0·5 per cent. novocain-suprarenin solution will be ample.

These injections having been completed, the leg can be constricted at the thigh to render it bloodless. As a rule complete anæsthesia of the entire leg below the knee and foot will supervene in about ten minutes, so that any operation on the soft parts or bones can be

performed painlessly. Baisch recommends this method of inducing local anæsthesia for the **correction of contracted club-foot.**

For **resection of the knee-joint** Hohmeier has proposed the following method of local anæsthetization. First perineural injection of the N. tibialis and peronæus (internal and external popliteal nerves). The first he anæsthetizes according to the method above described, the latter he reaches by bending the knee and behind the biceps tendon immediately after the division of the main nerve into its two branches. He then circum-injects the cross section of the limb and the subcutaneous tissues for a hand's breadth above the knee-joint.

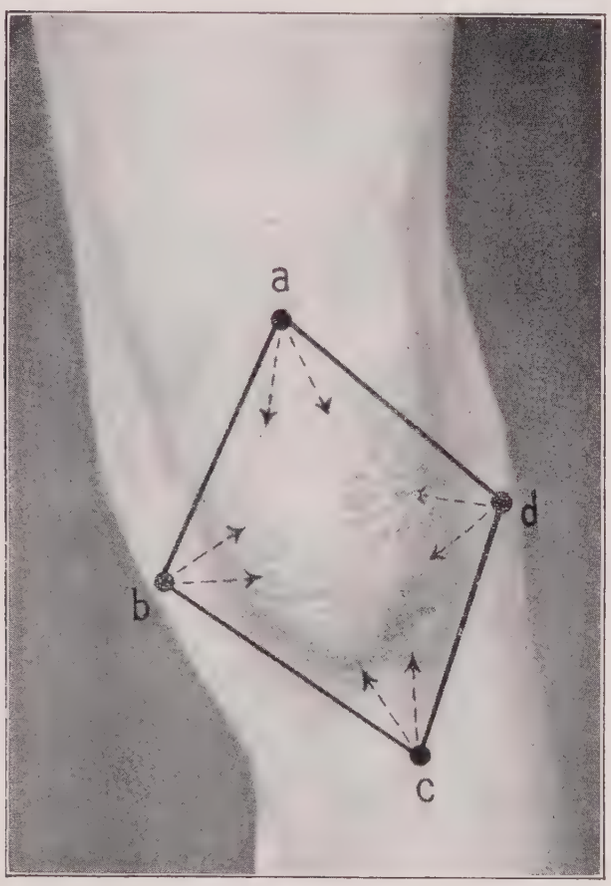

FIG. 102.

(The dots indicate deep injections, the arrows subcutaneous ones.) Finally, he infiltrates the line of incision over the patella and gives a few deep injections into the parts of the tibia adjacent to the joint. The quantity of 0·5 per cent. novocain-suprarenin solution used is 270 c.c. Anæsthesia supervenes in about five to ten minutes.

For operations restricted to the **patella** (wiring) or the **pre-patellar bursa** (excision) circular injection of the patella is sufficient, as shown in fig. 102. At points *a*, *b*, *c*, *d*, wheals are raised by endermic injection; the points are then united by subcutaneous infiltration. In addition to this, deep injections are made in the directions indicated by the arrows, the needle being inserted down to the bone of the patella. Finally, several cubic centimetres of

the solution are injected into the knee-joint from points *b* and *d*; 30 c.c. of 0·5 to 1 per cent. novocain-suprarenin solution will suffice for the procedure. In the case of excision of the bursa patella the last part, the injection into the joint, is unnecessary.

As we have said, the anæsthetizing procedure in the popliteal space permits of any operation being performed painlessly on the foot and toes, so that it would seem superfluous to inject the individual parts of the metatarsus or the toes.

In **operations that only affect the toes** local infiltration may nevertheless be recommended on account of its being more simple.

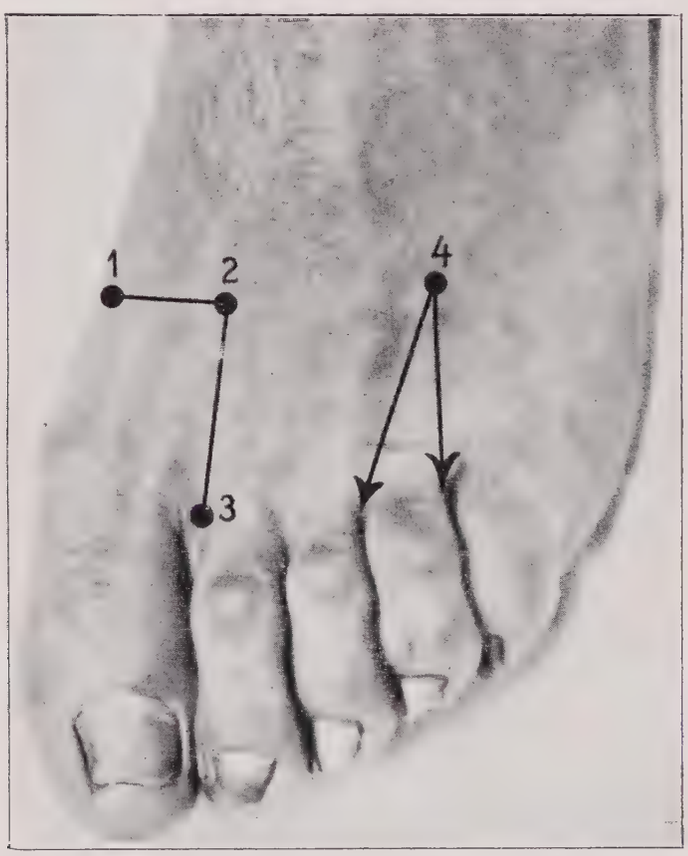

Fig. 103.

Oberst's method, as described for the fingers, is most suitable for the purpose.

For **operations on the great toe** (exarticulations, operation for hallux valgus, removal of foreign bodies, &c.), the method described by Braun may be used. Three points of puncture are indicated by wheals (fig. 103, 1, 2, 3), one at the medial (internal) border of the foot, the second on the dorsum, and the third in the first interdigital fold. The needle is introduced at 2, and, injecting as one goes, pushed through the first interosseous space until it can be felt under the plantar skin. It is better not to push it into the skin itself as this causes pain. Besides this the subcutaneous tissues between 1 and 2, and the soft parts in the sole of the foot from point 1

to a point lying in the first interosseous space and corresponding to the plantar point 2, are infiltrated. Finally, subcutaneous injection is carried from 3 to 2, as well as deep injection into the interosseous space and under the skin of the sole of the foot. The anæsthetization of **the fifth toe** is carried out in a like manner.

In the case of the **three middle toes** one can also proceed as follows : From one point only, situated over the metatarsal bone (fig. 103, 4) injections are made subcutaneously in the directions indicated by the arrows towards the interdigital folds and deeply into the interosseous spaces. On the plantar side the same process is repeated from a point that would correspond with point 4 on the dorsum.

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